A Primer in the Art of Deception

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The Cult of Nuclearists, Uranium Weapons and Fraudulent Science

Paul Zimmerman

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The Builders

Henry Wadsworth Longfellow

All are architects of Fate,
Working in these walls of Time;
Some with massive deeds and great,
Some with ornaments of rhyme.

Nothing useless is, or low;
Each thing in its place is best;
And what seems but idle show
Strengthens and supports the rest.

For the structure that we raise,
Time is with materials filled;
Our todays and yesterdays
Are the blocks with which we build.

Truly shape and fashion these;
Leave no yawning gaps between;
Think not, because no man sees,
Such things will remain unseen.

In the elder days of Art,
Builders wrought with greatest care
Each minute and unseen part;
For the gods see everywhere.

Let us do our work as well,
Both the unseen and the seen;
Make the house where gods may dwell
Beautiful, entire, and clean.

Else our lives are incomplete,
Standing in these walls of Time,
Broken stairways, where the feet
Stumble, as they seek to climb.

Build today, then, strong and sure,
With a firm and ample base;
And ascending and secure
Shall tomorrow find its place.

Thus alone can we attain
To those turrets, where the eye
Sees the world as one vast plain,
And one boundless reach of sky.

There once was a man named MacTavish,

Who attempted an anthropoid ravish.

The object of rape

Was the wrong sex of ape,

And the anthropoid ravished MacTavish.

Now It Can Be Told

"Now it can be told why depleted uranium weapons represent such a contentious flashpoint. The deployment of these munitions represents the first time in history of the mass contamination of populations by a single radionuclide. Never before have sufficient numbers of people received into their bodies the same radioactive pollutant so as to enable science to determine the impact to health of low levels of internal exposure. The creation of this cohort of victims represents the greatest threat to the nuclear programs of government that has ever existed and explains why every effort is being made to hinder medical investigation of ailing veterans and cover up the radiotoxicology of uranium. The victims of weaponized uranium have proven to be the proverbial canary in the coal mine. Uranium is of low radioactivity. Yet, significant numbers of veterans and 'enemy' civilians are manifesting a variety of illnesses never before associated with such low-level exposure to ionizing radiation. Inadvertently, the United States has trapped itself in a web of its own making. It has created a huge laboratory of victims contaminated with uranium who are being studied by independent investigators from all over the world. And what is being witnessed is an overall debilitation in health of the exposed populations. Before all of humankind, the suffering of those contaminated by depleted uranium weapons is testimony against the lie formulated by the developers of nuclear weapons and reactors — that low-level radiation is not a hazard to health."

From the chapter ***A Primer in the Art of Deception***

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A Word About Uranium

Uranium is the 92nd element of the periodic table. Each atom of uranium has 92 protons packed within its nucleus, and around that nucleus orbits 92 electrons. In nature, uranium is found in three varieties — three isotopes — that differ from one another by the number of neutrons sharing their respective nuclei. Uranium-238 possesses 146 neutrons, uranium-235 possesses 143 neutrons, and uranium-234 possesses 142 neutrons. The uranium found in the Earth's crust is a mixture of these three isotopes. 99.28% of the uranium found in nature is uranium-238. 0.71% is uranium-235. And 0.0058% is uranium-234.

In 1938, Otto Hahn and Fritz Strassman split the uranium atom. During the following year, it was discovered that the fission of uranium released neutrons that could proceed to split further uranium atoms thereby initiating a chain reaction that liberated the energy bound within atomic nuclei. Preliminary investigations into the possibility of creating an atomic bomb revealed that such an explosive chain reaction required a mass of uranium enriched to the point where it contained uranium-235 in a concentration of approximately 90%. On the other hand, the sustained chain reaction within a nuclear reactor required uranium fuel slightly enriched to a concentration of approximately 3-6% uranium-235. Prior to the fabrication of the first atomic bomb during World War II, industrial processes were developed for accomplishing the incredibly sophisticated feat of separating atoms of uranium-235 from those of uranium-238 — a difference in weight of a mere three neutrons. The pure uranium that was fed into this enrichment process was made up of the three isotopes in the same concentrations as the uranium found in nature. Flowing out from the process were two products. One was enriched uranium containing the required concentration of uranium-235 for nuclear reactor fuel or a nuclear weapon. The other was depleted uranium, uranium whose U-235 content had been depleted from 0.71% to

approximately 0.2%. Over the decades, the United States has accumulated an enormous quantity of depleted uranium, by some estimates equaling approximately 700,000 metric tons.

All atoms of uranium are radioactive. At some point in their lifetime, they spontaneously undergo radioactive decay and emit subatomic particles and energy from their nuclei. When this process occurs in the crust of the Earth, it is of no consequence to life. Decay while the atom is entrapped within the body of a living organism, however, is altogether different. When the radiation from a radioactive atom is released into a biological medium, it creates damage to the molecular structures that make up that living system. Living organisms possess natural repair mechanisms that are immediately activated when this type of injury occurs. The central problem in the science of radiation protection is to determine the dose of radiation and the rate of delivery that can be successfully managed by these repair mechanisms before irreparable harm is caused which, in time, manifests itself as altered functioning and ill health.

Uranium-238, which makes up over 99% of depleted uranium, decays very slowly relative to other radioactive isotopes. As an example, if you start with 1,000 atoms of iodine-131, over a period of eight days half of those atoms will undergo radioactive decay, emitting radiation into the surrounding medium in the form of particles and energy. Those 500 decaying atoms are transformed into the stable isotope xenon-131. With the passage of another eight days, half of the remaining 500 atoms of iodine-131 will decay, leaving only 250. This process continues every eight days, halving the remaining quantity of iodine until no more remains. In contrast, the half-life of plutonium-239 is 24,000 years. Starting with a sample of 1,000 atoms, it takes 24,000 years for 500 of those atoms to undergo radioactive decay, another 24,000 years for a reduction to 250 atoms, and so forth. Uranium-238 has a half-life of 4,500,000,000 (4.5 billion) years. Despite this long half-life, uranium incorporated into the human body is not radiologically benign. A tiny uranium particle one micron in diameter — one millionth of a meter — consists of hundreds of billions of atoms. Within this vast quantity, individual atoms are decaying on a regular basis, emitting radiation into the cells immediately surrounding the particle. Nevertheless, because uranium decays so slowly, the vast majority of health physicists are of the opinion that, in the concentrations likely to develop within the human body, it presents no hazard to health.

During Operation Desert Storm, the Iraq war of 1991, the United States deployed a new type of munition containing depleted uranium. This unique form of ammunition was heralded by the Pentagon as a superweapon of miraculous capability. Due to uranium's high density, rounds made of the metal can slice through any type of armor, render-

ing all tanks and land vehicles, airplanes and ships, vulnerable to penetration and destruction. There is only one drawback to this new weaponry. Uranium is pyrophoric. The high heat of impact sets it ablaze. The resulting inferno liberates huge quantities of microscopic uranium particles into the air which, if inhaled by soldiers on the battlefield or civilians downwind, can pose a detriment to health.

The Department of Defense of the United States has repeatedly affirmed that weapons containing depleted uranium present no radiological hazard to human health. In agreement with this assessment, a number of highly prestigious organizations from around the world have published studies declaring that the radioactivity of uranium represents no cause for concern. These include the National Research Council, the Department of Health and Human Services and the Rand Corporation in the United States, the Ministry of Defence and the Royal Society in the United Kingdom, NATO, the European Commission, the European Parliament, the World Health Organization and the United Nations Environment Program.

These official proclamations vouching that it is safe to scatter uranium dust over the surface of the Earth emit the stench of political propaganda. The science of radiation protection as it applies to internal contamination by uranium does not support the party line being peddled. The issues are far from being as clear-cut as the august authors of the official reports want us to believe. In fact, a great deal of evidence exists that suggests that uranium weapons can produce significant damage to health in those who inhale the radioactive aerosols.

The dispersal of radioactivity across the homelands of human populations is a direct challenge to the whole of humankind to come to terms with the true nature of uranium weapons. Either these armaments are as safe as their defenders claim, or they are recklessly and indiscriminately hazardous to human health. If the first option is true, we can rest easy in the knowledge that humankind and the biological integrity of our planet are being protected by the weaponeers and the scientific organizations that speak on their behalf. If the latter option proves true, it will bear ample testimony to the fact that humanity has indeed been the victim of an anthropoid ravish. It will indicate that all those highly trusted and respected institutions that issue defenses of militarized uranium are, like an omnipresent dark brotherhood, trafficking in falsehood so as to disguise the momentous misdeeds of those who field these weapons. The stakes being played for in the dispute over the safety of depleted uranium weaponry are these: Which version of reality will gain ascendancy?

Preface

Hear Ye! Hear Ye! Gather Round, O Readers, Gather Round! The infamous shell game is about to begin. But be forewarned. Vigilance must dominate your eye. With sleight-of-hand of dizzying agility, those who aspire to be Masters of us all audaciously proclaim that uranium weapons pose no threat to health. "Behold," they say, opening their heavy tomes. "The science is indisputable. Uranium, emitting low levels of radioactivity, is all but harmless when drawn into the interior of the body." And yet, in the wake of each deployment of uranium weapons, reports crash in upon our shores of once healthy people, our own soldiers among them, made ill. What are we to believe? We stand before our leaders dumbfounded. Their logic is impeccable. Their words ring true! Within the reigning paradigm, uranium weapons are, under most circumstances, benign. But be not blinded by the dazzling shell game, artfully crafted to confound the mind. Their fleeting hands are nimble. Mesmerized, we miss the blatant trick played out before our eyes. Uranium weapons remain cloaked within the guise of harmlessness because the reigning paradigm itself has been corrupted! What we are not supposed to see, what we can never be allowed to see, is that the science used to assess the hazards of radiation has been infiltrated and distorted so as to rob us of the truth. We of the twenty-first century, who put our faith in science as the prophetess of objective revelation, are easily tricked when science is made whore to political intrigue. And that is exactly what has occurred. The science of radiation effects has been made harlot to a political agenda so, with impunity, the peddlers of radioactive weapons can contaminate the earth.

As these words are being written, curators of the Outagamie County Historical Society in Appleton, Wisconsin are igniting the ire of magicians around the globe.

The exhibitors, in honor of their favorite son, Harry Houdini, have created a display that reveals the secret of the master magician's most famous illusion. The Metamorphosis trick is now an open book. Houdini, and generations of illusionists in his wake, captivated audiences by being shackled and handcuffed, tied within a canvas bag, locked within a trunk secured with chains and padlocks, and then escaping, switching places with an assistant on the outside, all within seconds.

In the spirit of the Outagamie County Historical Society, this book exposes stunning feats of deception. Science will be queried on the subject of truth as it applies to radiation effects to human health. And it will be science that will testify before all mankind the malfeasance at work within our midst. We have assembled before these pages to unmask falsehood and to ignite the Will to oppose further radioactive degradation of the Earth.

At its heart, this is a book about science, how science can be corrupted to become an instrument of the State, or how it can become an enemy of the State when allowed to speak unmolested. The science to be presented is written for the layman. It is as nontechnical as is possible while presenting very difficult and abstract concepts of radiation physics. The reader, patient enough to struggle with some of the difficult concepts presented herein, will be rewarded with truly astounding revelations. Both the great Truths and the great Falsehoods of the twentieth century lie hidden in the arcane, widely inaccessible, and seemingly mundane domain of the radiation sciences. It is into this territory that the Lovers of Truth must penetrate if they wish to expose, in the clearest and most undisguised visage, the machinations of those who hide behind nuclear/radiological weaponry.

Introduction

I have sworn upon the altar of God, eternal hostility against every form of tyranny over the mind of man.

Thomas Jefferson

On numerous occasions over the last 16 years, I have lectured alongside nuclear physicists, health physicists and radiation biologists at seminars devoted to teaching health-care professionals and first responders how to manage radiation emergencies. My expertise, acquired via self-education, is in the history of radiation accidents and the environmental effects of nuclear weapons and reactors. It was on this pilgrimage along the lecture circuit that I was first introduced to the mentality of the professional physicist. From the first, members of this strange fraternity took it upon themselves to take me aside and prep me as to the proper etiquette expected of a novice who broaches the topic of radiation physics in the presence of the almighty, degree-granted elite. Although never stated explicitly, the supreme edict did not take long to crystallize in my awareness: When in the presence of professional physicists, health physicists, radiation biologists and nuclear medicine physicians, it is forbidden to utter a single syllable that may in any way be construed as a criticism of any form of nuclear technology. To violate this canon is to toll a death knell to your

credibility. If, by even a single word, you so much as suggest that you are not 100 percent in support of the way radiation exposure to the public is being managed, you are branded "ANTI-NUCLEAR." In professional circles, this is a derogatory term intended to defame the character of the person who has fallen out of step with his colleagues. Once besmeared with the slur "anti-nuclear," you become a pariah in the community of trained scientists. Your scientific objectivity is assumed to be tainted by your politics. Your motives are suspect. Your views are received by derisive smirks and eyes floating upward to investigate the pattern of the ceiling tiles. In short, you are dismissed as a frivolous upstart trespassing within the hallowed domain of the august stalwarts of scientific objectivity.

Being a spy from the humanities, I was dumbfounded by this close-mindedness and unconquerable tyranny over thought. Within the milieu of the nuclear scientist, the entire gamut of nuclear technology was to be embraced with hushed acceptance. No investigator, if he wished to be taken seriously, could have an opinion, or at least voice an opinion, that deviated from the mainstream of the nuclear establishment. Physics, to remain pristine, was to be confined to the laboratory, and legitimate topics of conversation were restricted to subjects suitable for the scientific journals and the international conferences. The scientists whom I met acted as if the entire enterprise of science would be defiled and subverted if representatives of their discipline became tainted by a political discussion.

This fervent defense of the realm of physics by its trained knights was paraded before me as a noble tradition. But in time, their claim of preserving disinterested science appeared disingenuous. As I penetrated the depths of the many issues being sidestepped in the name of objectivity, it became blatantly clear that the posturing I observed was in fact a political act in itself. Since the Manhattan Project during the Second World War, the academic discipline of nuclear physics has become irretrievably intertwined with the political enterprise of building weapons of mass destruction. This has cast a pall over the entire discipline. As Robert Oppenheimer[1] is famously quoted as saying: "In some sort of crude sense, which no vulgarity, no humor, no overstatement can quite extinguish, the physicists have known sin, and this is a knowledge which they cannot lose." With their science married to nuclear weapons, physicists are like children who grow up within a dysfunctional family. One parent embodies the noble quest to unlock the secrets of the universe while the other is bent on devising new methods for decimating large segments of humanity. Out of this mixed and dreadful pedigree, each new member of the profession has to forge a professional identity he can live with. Apparently, within the climate of the professional physicist, a common survival strategy is to disallow upstarts such as myself from raising uncomfortable questions about the real-world applications to which their science is put by govern-

[1]Oppenheimer was scientific director of the Manhattan Project which built the first atomic bomb.

ments and armies. What I came to understand was that the fervid intolerance of "anti-nuclear" points of view, whether intentionally or not, served an important political purpose. The respected discipline of physics and the well-intentioned scientists who swell its ranks are pawns that front for the nuclear programs of government ensconced behind them. The physicists stationed in academia are the perimeter defenses for the entire nuclear establishment. They are the forward guard who, while defending the integrity of their discipline from "anti-nuclear" sorties, simultaneously offer a tacit defense of the militarization of physics that is taking place within their rear. Their cries for keeping science free of politics camouflages a terrible truth: The science of radiation effects has already been compromised by a political agenda. It has been infiltrated and subtly corrupted by scientists sympathetic to the further development and use of nuclear and radiological weapons.

Starting with the Gulf War in 1991 and continuing to the present, the United States has fielded uranium weapons on the battlefields of its enemies. In defense of this practice, government spokesmen have repeatedly affirmed that such methods of warfare do not present a radiological hazard either to our own troops or to enemy populations. Anyone with even a rudimentary knowledge of radiotoxicology and the hazards of alpha-emitting radionuclides knows this statement, made unconditionally, to be a lie. One might hope that in response to such prevarication, scientists of integrity, not compromised by government employment and lucrative payoffs, would raise their voices to correct this propagandistic misrepresentation of the facts. But instead, with few exceptions, there reigns an eerie silence.

In this instance, a field of study, namely the radiotoxicology of uranium, has become politicized. This subfield of radiation biology is little understood by the general public and therefore subject to much misrepresentation by interested government organs. Faced with misinformation campaigns, it falls to the educated scientist to intercede on behalf of the public, clarify the issues, and rectify any distortions of truth. Whether those possessing knowledge of radiotoxicology like it or not, circumstances have recruited them to the front line of a political struggle. For those radiation scientists to excuse themselves from public discourse on the pretext of not wanting to tarnish their scientific objectivity is negligent in the extreme. The lofty ideal of disinterested science pursued in some otherworldly domain separate from the affairs of men is no longer a tenable stance. Those nuclear physicists and radiation biologists whom I met, so intent on silencing discussion of the political implications of their profession, fail to recognize that their supposed scientific neutrality and detachment is itself a political statement bearing political consequences. It is tacit support of the current political agenda. Silence in the face of government propaganda that is in obvious violation of established scientific fact is reprehensible. It is collusion with falsehood.

This apolitical posture of the nuclear scientist and the deafening silence that accompanies it is, at least partially, rooted in self-interest. Those engaged in the nuclear sciences are themselves vulnerable to the stigma of being branded "anti-nuclear." To earn this moniker is to court professional suicide. Your credibility as an "objective" scientist is tarnished. The stream of grant money and federal funds dries up. Your job is at risk. Future employment opportunities dwindle. You may perish because you can no longer publish. These are powerful motivators for retreating into your laboratory, closing the door, and refraining from discourses displeasing to the nuclear hierarchy. Victor Gilinsky, a member of the Nuclear Regulatory Commission from 1975 to 1984, described the marginalization promised to any dissenter of the nuclear status quo: "You're up against a pretty unyielding bureaucracy. No matter what you say, they will find a way of making you wrong" (Caufield). In an editorial in *Science* magazine, Philip Abelson, a nuclear chemist and one-time advisor to the Atomic Energy Commission (AEC), made the following observation:

> In questioning the wisdom of the establishment, [the scientist] pays a price and incurs hazards. He is diverted from his professional activities. He stirs the enmity of powerful foes. He fears that reprisals may extend beyond him to his institution. Perhaps he fears shadows, but in a day when almost all research institutions are highly dependent on federal funds, prudence seems to dictate silence (Caufield).

Moral cowardice is not the sole explanation for the current reign of silence. Something more insidious is at foot. Science, and with it truth, are being intentionally prostituted to advance a political agenda. A recent example will clarify this point. In April 2002, an article appeared in the journal of the Health Physics Society under the title "An Examination of Uranium Levels in Canadian Forces Personnel Who Served in the Gulf War and Kosovo" (Ough). The paper was authored by representatives of Canada's Department of National Defence, the Royal Military College, and the laboratories under contract which performed the analytical studies. It was meant as a progress report of a voluntary screening program in which Canadian veterans were supposedly tested for contamination by depleted uranium. What the report revealed instead, however, was a comedy of errors whereby the trust of veterans was abused by incompetent researchers whose intent was to prove that veterans do not get contaminated by depleted uranium while in service to their country. The report outlined the progress of bioassay tests conducted on 103 active and retired Canadian Forces personnel. Urine samples were collected, and an attempt was made to determine the relative concentrations of uranium-238 and uranium-235, a process which is required for accurately determining the presence of exposure to depleted uranium. But the researchers hit a snag. Veterans were informed that, due to the low levels of uranium-238 in their urine, it was not possible to obtain accurate uranium-235 concentrations. This perhaps was reassuring to the veterans. "Low levels. Good. Phew!" What was

left unspecified, however, was the fact that the two labs contracted to perform the measurements did not possess the equipment and expertise necessary to run the tests to the required sensitivity (Weyman 2003). In the last paragraph of the article, the authors, attempting to draw attention away from this debacle, tried to disparage proven analytical techniques with witless drivel: "In situations where these isotopic ratios [expressing DU] are required, either the analytical technique or the biological media being tested needs to be changed." Unable to provide useful information to veterans via the analysis of urine, the researchers turned next to an analysis of hair samples to test for evidence of DU contamination. Naturally, there was none. Unbeknownst to the veterans desperately seeking an evaluation of their health status, their negative test results were a foregone conclusion. To quote the website of the Health Physics Society (http://hps.org/publicinformation/ate/q450.html):

> *Hair analysis, however, is subject to numerous errors and the effects of contaminants, not a trivial problem in the case of uranium which is naturally present in water and soil. Hair analysis is not the standard nor an accepted way of evaluating exposure to or intake of uranium.* [italics added.]

According to the Agency for Toxic Substances and Disease Registry:

> Hair testing has very limited usefulness in medical practice, because it does not represent either the tissues inside the body or what is excreted. Hair analysis is only useful for detecting exotic compounds that are not normally found in the body. Thus, for example, a medicine that someone is taking, might be detected in the hair. Poisons, such as arsenic, also show up in the hair. Elements normally found in the body — such as copper, chromium, zinc, and even lead, mercury, and uranium — will show up in the hair, but the levels are quite variable and have little or no practical or clinical significance (Baratz).

To use hair analysis as evidence of depleted uranium contamination is charlatanism.[2] This is fraudulent science of the worst kind, published in a distinguished journal, purposely crafted to reinforce the false notion that uranium weapons do not contaminate people on the battlefield. Further, it is misleading to victims of such contamination who are at risk of becoming ill. They are prevented from obtaining objective information about what is going on inside their own bodies. This book relates many examples of such crimes against science and distortions of truth which serve, ultimately, as instruments of violence

[2] There is some evidence that hair analysis might be useful in the detection of *soluble* forms of uranium/depleted uranium. See Karpas *et al*., 2005. But as a means for detecting contamination with insoluble forms or the mixture of soluble and insoluble forms which accompanies battlefield exposure, hair analysis remains an unreliable test for determining exposure.

against an unsuspecting human race.

When the scientific method is betrayed and false information is promulgated in the guise of truth, all human beings are betrayed. Their minds become repositories of false ideas, planted there for political purposes. Having no objective frame of reference by which to evaluate the deeds of government, people are literally "dis-abled." They are robbed of the knowledge necessary to make their own informed judgment on important issues. Such a state of affairs is the precursor to tyranny and intellectual enslavement.

While reading the pages that follow, the reader must never forget that, behind the shenanigans and mischief permeating the hollow defense of uranium and other radiological weapons, lies real human misery, pain, and illness. Veterans are sick with an undiagnosed malady. Innocent populations in enemy states exposed to uranium contamination manifest similar symptoms. Bogus science, deceit and denial carry in their wake an ocean of human suffering.

The conspiracy to discourage scientific investigation into the possible relationship between Gulf War Illness and uranium contamination was breached in Paris on September 3, 2000 at, of all unlikely places, a conference of the European Association of Nuclear Medicine. There, research was presented that fired a shot across the bow of those working to mask the medical impact of uranium weapons, putting the United States government and the nuclear community on notice that conscientious science, not silence, will be the bearer of the truth for humanity. The presentation, later published under the title "The Quantitative Analysis of Depleted Uranium Isotopes in British, Canadian, and US Gulf War Veterans" (Durakovic *et al.* 2002) outlined a new protocol for testing for the presence of depleted uranium in urine samples using analysis by mass spectrometry. (A detailed description of this work appears elsewhere in this book). The research team collected urine samples from 27 veterans and definitively proved that depleted uranium contamination could unambiguously be detected at least nine years after exposure. This new methodology was no less than a weapon for the mass destruction of falsehood. Prior to this work, those contaminated by depleted uranium weapons could not be identified and the extent of their contamination could not be quantified. Consequently, armies could deploy uranium weapons with impunity. The new testing protocol opened the door for researchers worldwide to identify, in the aftermath of conflict, those whose health may have been forever compromised by contamination with the dust of uranium weapons.

One would think that the methodology developed by Durakovic, Horan and Dietz might have been received with accolades by US medical authorities searching for an expla-

nation of Gulf War Illness. For now, on the one hand, a protocol was available for determining depleted uranium contamination. On the other hand, a cohort of over 100,000 sick veterans suffering from an unidentifiable disease was waiting for medical attention. All that remained was sponsorship and funding for studies to establish definitively whether or not any relationship could be found between those veterans who are ill and the presence within their bodies of depleted uranium. Other studies could be designed to determine whether any relationship existed between the level of contamination and the seriousness of the illness or the presence of a defining collection of symptoms. Has the Department of Defense or the Veterans Administration rushed to employ this exciting technique for unraveling the mystery of Gulf War Illness? No!!!

The defenders of uranium weaponry are increasingly in trouble. To defend their claims that uranium weapons do not pose radiological hazards, they must now work within the arena of science, not by cover-up and propaganda.

Most citizens of the world's nations, far removed from the centers of power, currently lack the information to evaluate the radiological misdeeds being perpetrated by the government of the United States. The information as to which weapons contain uranium/depleted uranium and how much of this material is contained within these weapons is classified. No one knows how many tons of uranium has been dumped on Afghanistan and on Iraq since the current war began in 2003. The stewardship of the Earth has passed into the hands of politicians and generals who display by their deeds a devil-may-care attitude to the science of radiotoxicology and a century of research in radiation biology.

To conclude this introduction, I would like to offer a rebuttal to those scientists I met who attempted to marginalize this discussion by slandering as "anti-nuclear" dissenters to the policy of contaminating the earth with radioactivity. Only an uninformed idiot would be anti-nuclear. Humanity's understanding of the cosmos has been revolutionized by nuclear physics. The revelations of quantum reality are a prize of the twentieth century. Practically every scientific discipline has drawn upon the revelations of nuclear physics to develop tools and techniques for penetrating the mysteries of nature. Tracer chemistry has totally transformed the biological sciences and opened up previously opaque windows in such disciplines as physiology, biochemistry, genetics and immunology. New insights into the molecular basis of health and disease would not have been possible without the contribution of nuclear physics. Nuclear medicine has created powerful diagnostic tools in the service of human health. Multiple volumes could be penned in celebration of the benefits derived by mankind from nuclear physics.

Yet, in direct contrast to these truly magnificent human accomplishments are those acts which have resulted in the liberation of radioactivity into the environment. These have occurred through the development and deployment of nuclear and radiological weapons, through the failure of inappropriate storage methods for nuclear waste and through catastrophic accidents at nuclear power plants. *There is not a single life-enhancing benefit to be derived from releasing ionizing radiation into the environment.* I invite anyone to make a successful argument to the contrary. (Edward Teller, the father of the hydrogen bomb, put forth the ridiculous argument that radioactivity liberated into the environment would create the opportunity for beneficial mutations in the gene pool. He failed to note, however, the harmful mutations and cancers that would arise as well, in far greater frequency.) Ionizing radiation, by the energy that it transmits, ejects electrons from the atoms it encounters, creating pairs of oppositely charged particles that are reactive and have the capacity of creating chemical chaos in the surrounding medium. Ionizing radiation breaks chemical bonds, destroying in living systems biologically significant macromolecules, and as a result, altering biological function. On a planet teeming with life — impossible without the exquisitely precise interplay of biochemical choreography — ionizing radiation, concentrated by humans and then released, is a force of disorder, chaos and death. It is disruptive of living processes. That is its nature. It is a benefit to mankind only when contained and utilized under controlled circumstances. Haphazard dispersal creates nothing positive. Unnatural concentrations of ionizing radiation on the surface of the Earth are antithetical to life.

What follows is a thorough examination of the meaning and implications of the US government's deployment of deadly radioactive weapons. It is an unabashedly polemical essay intended to counter the reigning despotic silence and the unstated, politically motivated "pro-nuclear" bias contaminating much of the radiation sciences. The technical information is intentionally simplified to make the issues as widely accessible as possible. To ensure accuracy, all content has been reviewed by experts knowledgeable about the medical consequences of internal contamination by radionuclides. It is their province through which I journey, and it is upon their shoulders that the protection of the Earth depends.

1

A Fable for the Nuclear Age

Bestirred by wanderlust, a fraternity of seekers set out on a journey of discovery. They fared beyond all signposts of the familiar until, in time, they came upon a dark, dense tangle of forest that at first reckoning appeared impenetrable. With scythes slashing through the ensnaring underbrush, their initial foray into the virgin thicket uncovered a mysterious pathway that, though seemingly well defined, had obviously never before been traveled. Amazed by their good fortune at having stumbled across so worthy an avenue of exploration, these sincere lovers of truth vowed to map their journey wherever it might lead. Trekking off into the unknown, they traveled far and witnessed sights that never before could even have been imagined. As these voyagers penetrated ever deeper into extraordinary mysteries, they eventually passed beyond the veils of this life altogether into a new world in which no human being had ever set foot. At first they were mesmerized and bewildered by the total lack of familiarity with all the new phenomena that greeted them. Unaccustomed to the swirl of shifting impressions, their minds had no framework by which to anchor their understanding. Rising to the challenge of making sense of the inscrutable, they spent years devoted to painstaking observation and rigorous calculation. Finally, through exhilarating leaps in imagination, they deciphered the play of energy that engulfed them. To their awe and amazement, they discovered that they were inhabiting the unseen world that formed the foundation of their home world. What they had come to understand were the laws governing the origin and fundamental structure of all physical reality. Their penetration into the unseen, driven by unquenchable curiosity, had unveiled embedded secrets of the universe that up to that time had been beyond the province of humankind.

Returning from their expedition into the divine, the wayfarers, no longer novitiates

but masters, were shocked to discover that calamitous events had swept over the land. A tyrant had mobilized a vast, thundering army of darkness and had begun systematically to overwhelm and enslave the entire world. Threatened by the encroaching evil, and in a moment of ethical weakness, the explorers petitioned the warlords of their city for an audience with the promise of providing them with certain insights that might be of use to them in achieving victory over the enemy.

Humoring these seemingly eccentric petitioners, the warriors ushered them into the innermost sanctuary of their citadel. They planned to give but mocking ear to whatever unpurposed strategy these unmilitary minds entertained. Not long into the exposition, however, the smirks on the warriors' faces gave way to agonizing concentration as they grappled to make sense of the strange tale recounted to them of the wizards' remarkable journey. In the midst of profound befuddlement, their primitive minds were able to comprehend a small crumb of the tale, something about the prospect of forging unlimited power from base matter and creating a new weapon of ultimate destructiveness.

Withdrawing from their guests to confer in private, the warlords confessed to each other their total mystification over what they had heard, their complete ignorance of otherworldly matters, and the hopeless inability of their corrupted natures of ever retracing the refined pilgrimage made by the wizards. Nevertheless, what they had gleaned from the wizards' narration astounded them. To their minds, the evil deity whom they worshipped was delivering the answer to their prayers. Like a miracle, dominion, not only over their enemies but over all the Earth, was being handed to them. All that was required for the fulfillment of their fiendish covenant was to somehow seize the knowledge that had been entrusted into the hands of the wizards, embody it in a workable design, and construct a revolutionary implement of cataclysmic proportions. Their exaltation quickly gave way to grief, however, when they recognized that they had not the capacity to complete the great work laid out before them. Duplicity was all that they could bring to the endeavor, and so with that, they devised a plot to enter into alliance with the wizards so as to steal their science and make it their own.

Rejoining their guests, the warlords made great show, feigning the deepest respect for the wizards and ostentatiously lauding them with praise for their wisdom and loyalty. They provided a magnificent feast, sparing no expense, and wined and dined the wizards into an intoxicating state of mutual fellowship. Then ceremoniously all together, the warlords got down on their knees and humbly entreated the wizards to guide them by whatever means necessary to victory over the approaching tyrant. They solemnly pledged to put the full resources of the realm at the disposal of the wizards, to provide them with a key to the treasury, and to enlist whatever manpower was required.

Made giddy by this outpouring of esteem from these crass but powerful warriors, the wizards marveled at the tantalizing invitation before them to put their arcane knowledge to practical effect. Recognizing that the proposed endeavor, an inviting new journey of discovery in itself, could never be undertaken without the support of such powerful patrons, they consented wholeheartedly to a collaboration with the warlords.

Straightaway the wizards retreated to their laboratories, intent on conjuring a plan that could successfully unleash the power of the unseen on the tyrant and his forces. A blueprint for victory quickly crystalized. Through powerful alchemy, the wizards proposed to construct a portal through which they could funnel the abundant energy of the invisible world into this world, creating a shattering discharge at any site of their choosing. The scale of so monumental an undertaking, however, seemed staggering. New tools were required. Exotic material never before existing on the face of the Earth had to be created. Gargantuan workshops needed to be erected. And vast legions of apprentices had to be recruited and trained. With a workable design for the massive undertaking in hand, the wizards returned to the warlords with a shopping list so long that it looked to drain the economy of the entire province. The warlords, intent on providing whatever was necessary to bring to fruition their own clandestine scheme, promised to deliver all that was requested.

Seduced by unquenchable curiosity, lured by the vast wealth at their disposal, and enchanted by the incredible power they had been invited to play with, the wizards began without hesitation to entrust the secret knowledge into the hands of the warlords. And with each new revelation, the warlords in turn sent orders to their minions on how to carry out the construction of the portal. The wizards first instructed the warlords to mine the Earth for certain rare ores and then taught them how to transform these base rocks into a talisman of pure potential. They revealed the magical processes for extracting a vital essence from the talisman and then concentrating it. In an amazing *tour de force*, they then disclosed the secret alchemy that transmuted within powerful furnaces this vital essence into the substance of the portal. They then taught the final trick of how to open the portal, and with that, the transmission of their knowledge was irrevocably accomplished.

As final assembly of the portal neared completion, a sardonic act of providence insinuated itself into everyone's plans. A courier arrived in the city bearing news from the front: the tyrant had been defeated on the field of battle and his cohorts were in chaotic retreat. Only islands of opposing diehards resisted capitulation, but their ruin was imminent. The people of the city rejoiced. Peril no longer threatened; victory was at hand.

The news was received by both wizards and warlords with solemn reserve.

Delivering a working portal to the world had taken on a life of its own, independent of the outcome of the current conflict, and victory now threatened to disrupt the whole enterprise prematurely. The wizards longed to bring into being and thus confirm their otherworldly visions. The warlords lusted to unleash upon the world the surprise they had been preparing. Rather than slackening, the work accelerated with a renewed urgency.

Finally, having meticulously applied all the instructions dictated by the wizards, the warlords had in their possession a workable portal. To remove any lingering skepticism as to the workability of their new creation, and intolerant of being victims of a colossal jest, both parties concurred that a test of the gadget was in order. All together, the collaborators gathered at dawn on a plain in the wilderness to unlock a portal for the first time and witness firsthand the influx of the invisible world into their own. That they were tampering with the established order of the Earth did not even cross their minds. Irreverence was the order of the moment. The warlords wanted confirmation of their power. The wizards wanted confirmation of the sweetness of their calculations. So emboldened by this moment of final proof of their mastery, the wizards were even taking bets among themselves as to whether or not the opening of the portal would ignite the entire atmosphere in a consuming fireball.

The test was made ready. The time had arrived. The portal was opened.

No amount of forewarning or imagination could have prepared them for what they had unleashed. Night instantaneously turned to day as the sun, in an instant, seemed to rise from the west and washed out all sight in blindness. A blast of heat seared their flesh. An unearthly roar deadened their ears. And the ground under their feet trembled with an earthquake. As one body, they fell to their knees with their heads in the dust. For one silent moment they were united in humility before the power of the Creator, the mystery of His phenomenal creation, and their own utter insignificance in the scheme of things. In that posture, in unison, they also came to realize that a breach between the worlds had been irrevocably opened and that the delicate balance of Life, evolving unhampered through millennia, was no longer safe from human intervention. The moment passed as quickly as it came.

Jumping to their feet, the warlords brushed the dirt from their clothes, thanked the wizards, still groveling in the dust, for their help, and strode off to make plans for the construction of further portals and to devise a stratagem to obliterate revengefully every last remnant of the enemy forces. Realizing in an instant in utmost humiliation that they had made an egregious error in judgment in aligning themselves with the warlords and transmitting to them the secret of the portal, the wizards ran after them hoping to redeem them-

selves by somehow tempering the future deployment of the catastrophic weapon. Catching up to the warlords, they exerted every ounce of their combined genius in an ardent plea to rekindle a mutual collaboration in plotting the future of portal technology. They advanced the pros and cons for utilizing the weapon in the mop-up operation that still needed to be waged against the remaining enemies. In high-minded oration, they endeavored to convince the warlords that the portal presented the perfect opportunity for eternal peace between all the lands since further warring would be too horrific. With lofty speech they painted a picture of a governing league over a united world that protectively held unilateral command over all aspects of portal technology.

Such misplaced idealism filled the warlords with scorn, and to communicate their disdain, all simultaneously put their fingers in their ears. A spokesman for the warlords then took the fore to unequivocally put an end to such foolishness and to clue in the wizards as to the lowly stature in the alliance they would henceforth occupy. Yes, the wizards were a smart bunch of fellas, he acknowledged, but their ignorance of worldly affairs was laughable. The hearts of men were too untamed to join in mutual cooperation. Power ruled and now the warlords were all powerful. They planned to maintain supremacy over all the lands by the indomitable force of the portal and to create a lasting peace by evoking terror in the hearts of friend and foe alike. The warlords had become wizards themselves in the course of constructing the portal, and they planned to tame the portal for unlimited energy and usher in a new golden age. He thanked the wizards for their blind naiveté and their unintended complicity in anointing the warlords as new masters over all the world. He concluded by inviting the now deflated comrades to tag along in their rightful position as lowly technocrats in the shadow of the warlords' ascension.

The harsh, insightful diatribe smothered the wizards in humiliation. Disillusioned by all they had heard, most of them retreated into the wilderness to nurse silently their shame. A few, endlessly mesmerized by the portal, stayed on to serve the warlords.

Intoxicated by their mastery of the portal, the warlords unflinchingly delivered their newfound might to an unsuspecting world. They smuggled a portal into the camp of enemy holdouts and opened it. In an instant the camp was leveled to microscopic rubble and every living thing within was incinerated. Three days later a second camp was obliterated from the face of the earth. The remaining combatants, dumbfounded by the unprecedented might of the warlords, capitulated immediately.

Capitalizing on their enhanced prestige and indomitable might, the warlords gorged their treasuries by extending their influence to their advantage into the affairs of all the peoples of all the lands. And while promoting peace to replace the previous cycle of con-

flict, they surreptitiously built an arsenal of portals in preparation to annihilate any unruly people who might dare challenge their authority.

Nor were they content to stop at that. Expanding on the inventiveness of the wizards, the warlords improvised new uses for the portal. Learning to open a portal gradually and harness its release, they created unlimited energy to power the machines of their artisans. They developed exotic modes of transport run on portal power. They developed energy beams that were effective in penetrating diseased tissue and healing the sick. They even developed impenetrable armor out of the material from which the portal was fabricated. Every facet of the city began profiting in some fashion from the new inventions. Portal technology was worshipped as a cash cow as it bloated the coffers of every sector of the society.

In the midst of this boom of economic expansion, a few of the wizards who had been dwelling in self-imposed exile arrived at the citadel of the warlords. From outside the walls they called up to the warlords who gathered on the ramparts above to give them ear. In a sign of profound humility, the wizards picked up dust from the ground and threw it on their heads. Then a crier from amongst them delivered a startling message: "We were foolish ever to think ourselves masters of anything. We come to you now as ignorant novices of the science to which we gave birth. The material from which the portal is constructed is far more dangerous than we ever imagined and produces consequences that were never intended. It is a monstrous poison. Its very presence on the Earth is an insult to all life. It emanates such power that the body of every living creature that comes in contact with even the smallest bit of it begins to dissolve. The mines. The workshops. The power stations. The garbage dumps. All are contaminated with the substance of the portal. All who approach these sites will become ill. And from these sites, the substance is escaping and spreading to every corner of the world. But this is not all. Every time a portal is open, the immeasurable influx of energy alters the very dust of the Earth into deadly poisons that pollute the waters, contaminate the lands, befoul the air. These poisons are so insidious that they will dwell amongst the living for untold thousands of years into the future and continue to murder the unsuspecting who innocently come in contact with it. You must cease your fixation with the portal or vast tracts of the land will become uninhabitable forever."

Indifferent to the news, the warlords turned away. What occurred outside the citadel was of no concern to them. If what the wizards spoke was true, any and all who suffered from the mysterious poison were but nameless martyrs to the warlords' eminence.

Little time passed before Fate dealt a cruel blow to the shortsighted arrogance of the warlords. A spy from within their camp stole the secret of the portal and gave it to

enemy warlords of a neighboring land. It did not take long for them to construct their own portal. And then in an act of terrifying intimidation, they opened the portal on the frontier between the two lands and toppled their enemies from their supremacy over all the people of the Earth.

The warlords from the two opposing cities squared off against each other and began stockpiling enormous numbers of portals for the eventual conflagration that would inevitably break out between them. Refusing to live in the shadow of such terror undefended, other cities developed their own portals. Not to be outdone, even powerless rogues managed to acquire portals through thievery or bribery so as to threaten mischief wherever they so desired. And as this devilish competition unfolded around the Earth, the innocents of all the lands silently trembled and wept.

While sanity reigned, the world carried on in a precarious peace. No warlord dared to open a portal in the midst of an enemy for fear of unacceptable retaliation.

This standoff, though providing a uneasy peace, was nevertheless an unending source of frustration to the warlords. They had expended so much on portal technology to achieve eminence above all the peoples of the world, and they were thwarted from actually deploying the portal against their enemies. Some situations made this impasse simply untenable. Frequently, skirmishes would break out on the frontier as barbarian hordes attempted profitable incursions into the land. The impulse of the warriors was to rid themselves of these pesky laggards forever by simply opening a portal in their midst. But the fear of retaliation from other portal powers forestalled this option. What to do. So much power and no way to use it. Years of anguished contemplation were expended on attempting to find a way to circumvent this dilemma. Then one day, in a moment of fiendish epiphany, one amongst the warlords made a breakthrough. Meditating on all the mountains of poisonous waste befouling the land that had accumulated in portal production, the idea dawned of dispensing with it by scattering it all over the lands of their enemies. Disguise the offal in conventional weapons, find some excuse to engage in minor skirmishes, and disperse the poisons over the lands and waters of the enemy. This would slowly and painfully poison the population of their foes and initiate mysterious epidemics among their children. Future generations would be born with hideous defects. Best of all, this process would be perpetual due to the extremely long life of the poisons. Anyone in the future taking up residence in the poisoned land would be invisibly contaminated as well. A clean and brilliant way to cull the populations of the undesirables.

So the warlords built their new weapons. And with every opportunity they deployed them. And when hostilities subsided, the people with whom they fought developed terrible

plagues of undetected origin. And terror filled the hearts of the victims.

As time passed, more and more lands were polluted by the terrible new weapons. Sensing the invisible, unleashed threat, all the creatures of the Earth were steeped in trepidation. And all the innocent people from throughout the world were filled with rage at the warlords and their contemptible disrespect for life.

And then mysteriously, not undertaken by any premeditated strategy, delegations of innocents began to appear outside the citadels of all the warlords of all the lands. Calling out to them sheltered behind their insurmountable walls, these innocents delivered a common message.

"We speak for all humanity. The vast majority of us dwelling on the Earth are simple, unassuming people. We cherish the harmony that exists between us. We abhor war and violence. Gladly would we live out our days in peace. Our aspirations are modest. We are content to find delight in the simple things of this life. Sufficient is a livelihood, a little food, shelter. We are thankful for the opportunity to pursue learning, to play and develop our bodies, to worship, to find the fulfillment of our hearts, to discover the love of a mate, to delight in the raising of our children and the imparting of our wisdom to them. We nurse our sorrows quietly and appreciate the giving and receiving of tenderness, charity and compassion."

"While you were amassing your arsenals, we were, to our shame, distracted by our personal concerns and content to let you beat your chests and leave us in peace. But now you threaten us all and seem quite willing to indiscriminately annihilate so many of the amazing life forms that share this planet with us. We have not the strength to oppose you. We have not the commitment to set aside our preoccupation with worldly goods and unite to fight actively against you. But let us make one thing unmistakably clear. If you dare to continue to wreak havoc on our beautiful world, either by portal war or the insidiously slow poisoning of the lands, those of us who manage to survive will hunt you down. Never will you be conquering heroes. We will storm your ramparts. We will pull you down from your towers. We will post to all future generations that you were the vilest criminals ever to emerge from our species. We will take vengeance on behalf of all of life and eliminate you and your kind forever from the face of the Earth."

2

The Cult of Nuclearists

Mischief is afoot in the science of radiation effects. An epic deception has been created to deflect criticism from those who scatter radioactive material over the Earth. This deception, created to fulfill a political agenda, has corrupted the understanding of what constitutes a safe level of exposure to radioactive atoms drawn into the human body from nuclear pollution. As a consequence, the health of vulnerable populations around the globe is being eroded.

Who would possibly commit such a crime? How could it be accomplished? What would be the payoff?

In setting out to write a book about fraudulent science, an obvious first step would be to reveal who perpetrated the fraud. In this case of widespread, institutionalized corruption, unmasking the collaborators is not feasible. No whistleblower has stepped forward. No misplaced memoirs have been discovered, stuffed between the pages of a discarded book. No posthumous confession has yet been bequeathed to posterity. Nevertheless, those who committed the offense are not as invisible as they believe. Revelation comes from an unexpected quarter.

Inevitably, people make a mistake who attempt to redirect, or misdirect, understanding of physical law and the phenomena of nature. Their hubris blinds them to their ultimate undoing, that in time, nature itself will reveal their intrigue. New technology, novel experimentation, a reinterpretation of existing evidence and the like will eventually conspire to highlight any disparity between objective truth and political propaganda. And this is what has occurred.

A Primer in the Art of Deception

The thesis of this book is straightforward: those who have monkeyed with science have left their signature in their works. Their corrupted science testifies against them. By their deeds, you will know them.

In the chapters that follow, the treachery committed against mankind will be dissected. In what remains of this chapter, context will be given for all that follows. In the process, similar to discerning campfires of the enemy camped just over the horizon, the army maneuvering against human freedom and safety will make itself known.

The fable of the foregoing chapter is an allegorical representation of events surrounding the creation of the first atomic bomb. The Manhattan Project was, without question, the most consequential event of the twentieth century. If mankind manages, at some point, to immolate itself in thermonuclear war, those crawling out from the rubble may heart-wrenchingly conclude that the Manhattan Project was the defining moment in the entire history of our species. The overriding importance of the Manhattan Project to human affairs, surprisingly, lies not in it having given birth to the atomic bomb. The appearance of the bomb in human affairs was inevitable. Nuclear energy is hidden in every atom of creation, and it was only a matter of time before someone, somewhere, developed the technology to cataclysmically release it. No, the momentousness of the Manhattan Project lies elsewhere, in the people into whose hands the knowledge of nuclear fission was transmitted.

Many fine histories have been written of the development of nuclear physics after 1900 and the culmination of this early study in the mushroom clouds over Hiroshima and Nagasaki. But the story is far from exhausted. No greater tragedy was ever suffered by our species than what transpired during the Manhattan Project. As in classical Greek tragedy, the story that unfolded during World War II involved the reversal of fortune of epic heroes, in this case the community of theoretical nuclear physicists. These men were deeply devoted to their science and embodied that capacity, which defines us as a species, to ascend to the heights of creativity and knowledge. Throughout the early decades of their century, they set out on a journey of discovery, traveling into the heart of matter. Navigating by simple scientific experiments and the power of their intellects, they passed beyond the veil of the visible material world and entered the unseen, invisible world beyond. There they explored the uncharted territory of the atom. By allowing their understanding to break free from the physical laws that govern daily life, they mapped a new reality which operated under unfamiliar laws. The knowledge which they reaped was brought back to the rest of humankind in mathematical formulas and scientific treatises that made the nature of the atom tangible. Similar to Prometheus stealing fire from Zeus, the early nuclear physicists returned to their fellows with knowledge of miraculous promise. A fount of unlimited energy

lay just beyond the veil. Perhaps, in time, it could be tapped for the benefit of humankind.

As decreed by immutable fate, worldly affairs intruded upon the noble enterprise of theoretical physics. Fascist ideology took hold in Europe. Whole nations were at peril. World war was imminent. And against this backdrop, humans discovered nuclear fission. In Germany in 1938, Otto Hahn and Fritz Strassman split the uranium atom by bombarding the nucleus with neutrons. Emigré physicists living in the United States pondered the implications of this accomplishment. And as they pondered, a haunting specter began to overshadow and besmear their pristine science. The darker implications of their discoveries began to make nightmares of their dreams. They foresaw the possibility that bombs could be fabricated in which a chain reaction in fissionable material could be initiated and briefly sustained. The resulting release of energy would produce a cataclysm that could destroy whole cities, tearing down all proud monuments of civilization. Perhaps by a realistic assessment of the developing situation, perhaps by psychological projection, in the Jungian sense, of their own unconscious Shadow, they imagined that their colleagues in Nazi Germany were at work creating a fission bomb for Hitler. To avert this horrific possibility, these intellectually brilliant scientists volunteered to help the "good guys" get the bomb first. Here lay the tragic flaw that led to the reversal of fortune for all humankind: to avert catastrophe, the community of physicists enlisted to bring about the catastrophe themselves. Seduced by transitory worldly affairs, these men were transformed into blind instruments of geopolitical maneuvering beyond their control and understanding. Through shortsightedness and naiveté, they betrayed themselves, and all of us, and in the process delivered the means for destroying all human life and the life-sustaining capacity of planet Earth into the hands of people with primitive minds and global ambitions. The recipients used their gift, and continue to use that gift today, to further their own hidden political, economic, and spiritual agenda while the rest of humanity quakes.

Those into whose hands nuclear fission was delivered harbor a disturbing mentality. For them, the energy of the nucleus is power which they can exalt in, exalt themselves in. They have come to identify this power with THEIR power, and they choose to lord it over all the world. By possessing the means of releasing nuclear energy, they claimed the heights of Power, Dominance, Terror. This is the fruit of their corrupted imaginations. And the new world order which they created has driven humankind to the edge of a precipice.

Unbeknownst to those who first made forays into the world of the atom, their quest carried within itself a poison seed. The release of atomic energy on planet Earth is a supreme violation of the natural order. Life arose on planet Earth only because the extraordinary energy of the atomic nucleus remained locked out of the domain of life. Underpinning the visible harmony of our beautiful world and our healthy bodies, there

exists the invisible, energetic, chaotic atomic and subatomic universe. By nature's design, these dimensions remain, for the most part, compartmentalized and separate. There is good reason for this. The three-dimensional physical world in which we live cannot benignly contain the enormous energies locked within the nucleus of atoms. Following a biological blueprint, our bodies and the bodies of all other life forms are exquisitely structured from chemical bonds and their physiological processes are made possible by the laws governing chemical interactions. This divine choreography gained a foothold on planet earth and flourished largely because it was not overwhelmed by ionizing radiation, energy which is intense enough to break chemical bonds apart. As life developed, it did so within the parameters of the terrestrial and cosmic radiation impinging upon it. This radiation sometimes disrupted chemical structure and severed the bonds between atoms. To counteract and neutralize this force of disintegration, biological mechanisms evolved in living systems to repair radiation damage within cells. However, a limit always existed beyond which living systems would be overwhelmed, their integrity hopelessly disrupted, so as to be rendered incapable of repairing certain types of damage induced by ionizing radiation. These limits are clearly evidenced in such phenomena as acute radiation syndrome and radiation-induced malignancies.

Until the advent of nuclear physics, the chemical, and thus biological, order of the natural world was immune to human tampering. All life forms on Earth were under the rule of natural law and safe from having their physical integrity hazardously disrupted by the unnatural impingements of ionizing radiation. But the human invasion of the atomic nucleus, and the retrieval of the secrets by which this realm operated, carried with it the potential of wreaking havoc in the domain in which we live our lives. Here is where the problem resides. Nuclear pollution is antithetical to life. Radiation breaks apart the molecular structures that make life possible. In the ordered world in which we carry out our lives, radiation is a force of chaos and destruction. Introduced into the human body, or into the bodies of all creatures for that matter, radiation promotes chemical disruption, biological deregulation, illness and death.

The statesmen who entertain themselves with the Great Game of redrawing the global map through war and subterfuge for the purpose of expanding markets, securing the natural resources of others and projecting power, entered a domain beyond their understanding when they acquired nuclear and radiological weapons. Pursuing their geopolitical ambitions as usual, they remained profoundly unschooled in radiation biology and the fact that their new weapons left residue upon the surface of the Earth that would endure for centuries and remain toxic to biological systems. This ignorance has been a plague upon the Earth since Hiroshima. Weapon testing has spewed radionuclides over the Earth. The weapon labs have vented radioactivity into the surrounding countryside. Radioactive

waste has been haphazardly buried, permitting the material to migrate into waterways and contaminate underground aquifers. Environmental degradation has been accompanied by a rising incidence of cancer and other illnesses in many contaminated regions. To mollify public concern over this state of affairs, governments have repeatedly issued assurances that their weapon programs were conducted within the boundaries of radiation safety. These assurances are political propaganda and complete rubbish.

In defense of the historical mismanagement of radioactive material, proponents of the technology argue that the worst pollution occurred during the nascent years of the Atomic Age, before increased knowledge demanded increased caution. By this line of reasoning, experience should have bred increased attention to environmental safety. The trust of this polemic was betrayed by the introduction of depleted uranium weapons into combat in 1991. New weapons and a new opportunity for their use led to a renewal of wholesale contamination of another people's homeland. Like their ancestors with clubs and rocks, modern warriors seek advantage over their opponents, but with this difference: they leave behind them a legacy of enduring nuclear pollution, and they don't give a damn.

Radiation safety as it pertains to internal contamination hasn't been ignored out of ignorance. The nation's weapon labs with their billion-dollar budgets are not in the business of making mistakes. The problem has arisen repeatedly because a *"disconnect"* occurs between those who understand radiation effects and those who don't. Regardless of how stringent safety measures are on paper or in the labs, once politicians and warriors get their hands on weapons containing radioactive material, the planet and the people are in jeopardy. A classic example of this occurred when open-air testing commenced in Nevada in 1951. Soon after, a heated controversy erupted between the Army and the Atomic Energy Commission over the issue of the positioning of troops during atomic warfare maneuvers. Initially, the AEC was extremely cautious, refusing to allow either troops or their own radiation-monitoring personnel to be stationed closer than six miles of ground zero at the moment of an A-bomb detonation. In opposition, the Army argued that it was appropriate and safe for troops to be positioned within less than a mile. In the end, the AEC caved in to pressure from the military, forfeiting its responsibility for radiation safety during military exercises. A similar type of disconnect occurred when Iraqi oil came up for grabs, transforming, once again, soldiers into guinea pigs. Prior to the first Gulf War, safety policies had been drafted for the protection of soldiers positioned in areas where DU weapons might be fired. Military command, however, failed to implement these policies or adequately instruct troops on basic radiation safety. As a result, soldiers received unnecessary exposure. The non-nuclear bunker buster bombs now being created are speculated to contain tons of depleted uranium. Although these weapons may be eminently successful in destroying enemy targets, what about the health of the men, women and children living

downwind? Military necessity always trumps radiation safety. Again, it is primitive minds in possession of weapons beyond their understanding that is humanity's bane. Or, as a darker alternative, it is very sophisticated minds that are using low-level radiation to deliberately debilitate the health of enemy populations.

Here is a truism that deserves pondering: People with a reverence for life don't drop radioactive material on other human beings. To make sense of why presidents and generals engage in such horrific deeds, only two options exist. (1) They don't understand the biological effects of the weapons they wield. In this case, they are acting irresponsibly, and these weapons should be taken away from them. (2) They do understand the biological effects of these weapons, but, nevertheless, continue to deploy them. In this case, they are acting as criminals, and again, these weapons should be taken away from them. There is no third alternative.

The disconnect between those knowledgeable of radiation effects and those who are not is further highlighted when engineering errors and accidents occur. It seemed like a good idea at the time at the Hanford Reservation in Washington state to store high-level radioactive waste from plutonium separation procedures in 177 huge stainless steel tanks. But the idea proved itself ill-conceived after 67 of the tanks leaked nearly a million gallons of the waste into the ground. Again at Hanford, it seemed like a good idea to pour 200 billion gallons of radioactive waste into evaporation ponds and seepage basins or bury it in trenches. The drawbacks of this practice only became known when the underlying aquifer, drawn upon for agricultural irrigation, was discovered to be contaminated and when radionuclides were found migrating into the Columbia River. The stack filters at Rocky Flats in Colorado worked as designed, trapping plutonium that otherwise would have escaped into the environment. But no one thought to change them before the fire in 1957 vented 250 kilograms of plutonium over Colorado.

Likewise, incorporating depleted uranium into weapons seemed like a brilliant idea. But the Starmet Corporation of West Concord, Massachusetts that manufactured DU penetrators erred in its waste management practices. Between 1958 and 1985, the company dumped 400,000 pounds of radioactive and toxic waste into unlined pits (Urfer). Ground water on the site is contaminated and radionuclides are migrating in the direction of the Assabet River. A similar environmental nightmare was produced by National Lead Industries in Colonie, New York. The company manufactured DU munitions, shields, ballast weights and armor (Urfer). In addition, it produced fuel from enriched uranium for experimental nuclear reactors (Urfer). While in operation, the facility contaminated nearby residential and commercial properties with DU. It vented DU into the air which was detected 27 miles downwind. Ground water at the site is contaminated with DU and has been detected in Patroon Creek downstream from the facility. Former employees of the

plant and nearby residents have been found to be internally contaminated (Parrish *et al.*). The factory closed its doors in 1984 after exceeding New York state radiation emission standards. The Sequoyah Fuels Corporation in Gore, Oklahoma was another facility that processed uranium for use in antitank ammunition. Closed in 1992, the 600 acre site is heavily contaminated with uranium and thorium and a variety of chemical compounds. Between five and 11 million cubic feet of radioactive waste litters the site (Urfer).

One of the most brilliant ideas of the nuclear age was conceived and carried out by technicians at a nuclear reactor in Pripyat, Ukraine. To carry out an unauthorized experiment during reactor shutdown, they knowingly violated safety procedures and disconnected at least six safety mechanisms, including the emergency core cooling system. Losing control of their system, they produced the Chernobyl debacle which succeeded in spreading a large fraction of the reactor's core over much of Europe.

Literally, hundreds, if not thousands, of these types of environmental insults could be cited from the worldwide mismanagement of radioactive material. But the point need not be belabored. An unbridgeable disconnect exists between knowledge of radiation safety and the ability of nonscientists in politics, industry and the military to respect and control the dispersal of this material. The nuclear genie grants wishes, but, once released from his lamp, spreads mischief around the globe.

The central question of this work is why, given humanity's near universal terror of nuclear and radiological weapons and the abysmal track record of the nuclear industry to contain radioactivity, do technologies endure that contaminate, or threaten to contaminate, the environment and massive numbers of people? The short answer is this: a clever campaign of misinformation has succeeded in making malignant deeds appear benign.

The early decades of the twentieth century were marked by extensive research into what constituted a harmless level of exposure to x-rays and internalized radionuclides. In 1934, a milestone was achieved with the international adoption of the first tentative standards of safety. Subsequently, this "permissible" level of exposure was repeatedly made smaller and smaller as the understanding of radiation effects became further elucidated.

In sharp contrast to the effort by medical professionals and researchers in the biological sciences to limit radiation exposure, the military application of radioactivity began taking all of humankind in the opposite direction. The detonation of atomic bombs, followed by thermonuclear weapons, produced unprecedented levels of external exposure and internal contamination to people living downwind of the test sites. In the decade after Hiroshima and Nagasaki, citizens quietly accepted the terrifying display of open-air testing,

first by the United States and then by the USSR. But as the environmental effects of nuclear weapons became widely known, people began to protest. A wave of incidents was reported throughout the 1950s that clearly demonstrated that weapon testing was not in the public's best interest. Radioactive fallout was detected traveling across the country from the Nevada Test Site. After Shot Nancy in 1953, thousands of sheep downwind of the detonation died under mysterious circumstances. Iodine-131, strontium-90 and cesium-137, among a host of other radionuclides, were detected in dairy products, meat and produce. Baby's teeth were discovered to be the repositories of strontium-90. In addition, downwinders began noticing, with increasing frequency, that neighbors, friends and relatives were developing thyroid diseases and leukemia.

Those people in government dictating defense policy were thrown into a quandary. Weapon development was top priority. But it could not continue unabated without quelling the concerns of the governed. An aggressive public relations campaign was initiated. The idea of the "Peaceful Atom" was promoted with the promise of energy "to cheap to meter." Newspaper reports of tests in Nevada were carefully crafted to minimize the perception that fallout was a concern. Major periodicals carried photo spreads of beautiful mushroom clouds growing out of pristine landscapes with accompanying text that expounded the safety of such testing.

Against this backdrop, a pivotal event occurred. In 1953, the International Commission of Radiological Protection published new safety standards for exposure to x-rays and dozens of radionuclides which hadn't existed in appreciable quantities prior to the Manhattan Project. In addition, a mathematical model was introduced by which dosages to people exposed to radiation could be calculated. This birth of the modern science of radiation safety was followed in time by the development of methods by which the risk of developing illness, i.e. cancer, among members of an exposed population could be estimated.

For the Atomic Energy Commission, charged with the conflicting duties of developing nuclear weapons, and later nuclear energy, while protecting the population from radiation, the new safety standards were a windfall. They provided the basis for establishing safe working conditions in the nuclear industry and the military. In addition, they were a shield, protecting the government from liability in cases where people sued, believing that their health had been compromised by nuclear pollution. For such litigants, the new standards of safety forced upon them the burden of having to prove that they had received a dose of radiation beyond the prescribed limits of safety. Although not recognized immediately, the newly developed science of radiation safety bore within itself an additional, priceless bonanza. Through subtle manipulation, it contained within itself the seeds for being

transformed into an instrument of political propaganda, defending the entire nuclear enterprise. It became the ultimate weapon against "antinuclear" opposition, invincibly defending as safe all acts that resulted in scattering radioactivity over the planet and into the bodies of unsuspecting victims.

Worldwide opposition to atmospheric testing helped force the signing of the Limited Test Ban Treaty in 1963. Subsequent weapon testing was forced underground. People around the world breathed a collective sigh of relief. Needless to say, the end of open-air testing did not put an end to the disquiet felt by many citizens of the United States about the health consequences of nuclear pollution. Issues of accountability and liability surfaced repeatedly, directed against the government and operators of commercial nuclear power plants, and these have continued unabated to this day.

One issue that dragged on for decades was whether veterans who believed themselves to be sick as a result of radiation exposure were eligible for financial compensation and health benefits. Between 1945 and 1962, an estimated 250-300,000 servicemen were assigned to areas contaminated with radioactivity. Some served in the Hiroshima and Nagasaki Occupation Forces, others were stationed at the Pacific Proving Grounds, and 80,000 participated in maneuvers at the Nevada Test Site "under the cloud," witnessing bomb detonations as close as 1830 yards away and then marching within hours through the swirling, contaminated dust to ground zero. Another liability issue that surfaced repeatedly from the 1960s onward revolved around the health consequences to downwinders living outside the Nevada Test Site. Many cancer patients believed that their illnesses were radiation-induced and sued for compensation from the government. Issues of contamination and disease also were raised by people living in proximity to heavily polluting installations such as the Hanford Reservation, Rocky Flats, Oak Ridge, the Savannah River Plant, the Fernald Feed Materials Production Center and the uranium enrichment facility in Paducah, Kentucky. In similar fashion, people filed lawsuits against commercial nuclear power plants for damages thought to be caused by routine or accidental emissions of radionuclides. A maelstrom of protest followed in the wake of the accident at Three Mile Island in 1979, bolstered by numerous reports of dead and injured farm animals and evidence of increased infant mortality (Wasserman *et al.*). To this day, the levels of radionuclides that were emitted from the stricken reactor, and the ultimate health consequences, are shrouded in secrecy. The furor over the irresponsible scattering of radioactivity amidst populations was reignited with the introduction of depleted uranium weapons into combat. Again, issues of liability and compensation are being waged as sick veterans strive to come to terms with their ruined health.

When discussing "liability," the reader should think **MONEY!** Proof that radiation

discharged into the environment causes illnesses would be astronomically expensive for those with an interest in nuclear weapons and the nuclear industry. ***These endeavors can only remain profitable and politically acceptable if liability can never be proven***.

Over the course of half a century, practically every effort by the public to prove injury from nuclear pollution failed. The government and the nuclear industry weathered each storm of protest and litigation, and in the process, mollified all opposition. They succeeded by appealing to protesters' naive faith that all proclamations made in the name of science were unblemished and objective. Their invincible strategy was based on beguiling the better judgment of all challengers with this seemingly irrefutable refrain: "The public has no need for concern. According to currently accepted international standards of radiation safety and risk assessment, the radiation released was in levels too low to create any adverse effects to health."

Behind this incantation dwells a coterie of individuals who derive power and profit from nuclear/radiological weapons and technologies that spew radioactivity into the environment. Throughout this work, this group will be designated by the term "*Cult of Nuclearists*." The use of such an oblique reference to point to the covert power structure of the United States is by no means original. For instance, in 1913, President Woodrow Wilson offered the following observation in his book *The New Freedom: A Call For the Emancipation of the Generous Energies of a People*:

> We have come to be one of the worst ruled, one of the most completely controlled and dominated governments in the civilized world — no government by free opinion, no longer a government by conviction and the vote of the majority, but a government by the opinion and duress of small groups of dominant men.

Wilson also provided this observation:

> Since I entered politics, I have chiefly had men's views confided to me privately. Some of the biggest men in the United States, in the field of commerce and manufacture, are afraid of somebody, are afraid of something. They know that there is a power somewhere so organized, so subtle, so watchful, so interlocked, so complete, so pervasive, that they had better not speak above their breath when they speak in condemnation of it.

The Cult of Nuclearists

President John F. Kennedy shone a light on the hidden power structure of the nation when he condemned secret societies and the threat they posed to free institutions. Addressing the American Newspaper Publishers Association in New York on April 27, 1961, Kennedy had this to say:

> The very word "secrecy" is repugnant in a free and open society; and we are as a people inherently and historically opposed to secret societies, to secret oaths and to secret proceedings. We decided long ago that the dangers of excessive and unwarranted concealment of pertinent facts far outweighed the dangers which are cited to justify it. Even today, there is little value in opposing the threat of a closed society by imitating its arbitrary restrictions. Even today, there is little value in insuring the survival of our nation if our traditions do not survive with it. And there is very grave danger that an announced need for increased security will be seized upon by those anxious to expand its meaning to the very limits of official censorship and concealment. That I do not intend to permit to the extent that it is in my control. And no official of my Administration, whether his rank is high or low, civilian or military, should interpret my words here tonight as an excuse to censor the news, to stifle dissent, to cover up our mistakes or to withhold from the press and the public the facts they deserve to know.
>
> Today no war has been declared — and however fierce the struggle may be, it may never be declared in the traditional fashion. Our way of life is under attack. Those who make themselves our enemy are advancing around the globe. The survival of our friends is in danger. And yet no war has been declared, no borders have been crossed by marching troops, no missiles have been fired.
>
> For we are opposed around the world by a monolithic and ruthless conspiracy that relies primarily on covert means for expanding its sphere of influence — on infiltration instead of invasion, on subversion instead of elections, on intimidation instead of free choice, on guerrillas by night instead of armies by day. It is a system which has conscripted vast human and material resources into the building of a tightly knit, highly efficient machine that combines military, diplomatic, intelligence, economic, scientific and political operations.
>
> Without debate, without criticism, no Administration and no country can succeed — and no republic can survive. That is why the Athenian lawmaker Solon decreed it a crime for any citizen to shrink from con-

> troversy. And that is why our press was protected by the First Amendment — the only business in America specifically protected by the Constitution — not primarily to amuse and entertain, not to emphasize the trivial and the sentimental, not to simply "give the public what it wants"— but to inform, to arouse, to reflect, to state our dangers and our opportunities, to indicate our crises and our choices, to lead, mold, educate and sometimes even anger public opinion.

Perhaps, most famously, President Dwight D. Eisenhower warned citizens of "unwarranted influence" and "misplaced power" by the "military-industrial complex" in his televised farewell address to the nation on January 17, 1961:

> A vital element in keeping the peace is our military establishment. Our arms must be mighty, ready for instant action, so that no potential aggressor may be tempted to risk his own destruction.
>
> This conjunction of an immense military establishment and a large arms industry is new in the American experience. The total influence — economic, political, even spiritual — is felt in every city, every statehouse, every office of the federal government. We recognize the imperative need for this development. Yet we must not fail to comprehend its grave implications. Our toil, resources and livelihood are all involved; so is the very structure of our society.
>
> In the councils of government, we must guard against the acquisition of unwarranted influence, whether sought or unsought, by the military-industrial complex. The potential for the disastrous rise of misplaced power exists and will persist.
>
> We must never let the weight of this combination endanger our liberties or democratic processes. We should take nothing for granted. Only an alert and knowledgeable citizenry can compel the proper meshing of the huge industrial and military machinery of defense with our peaceful methods and goals so that security and liberty may prosper together.

It is interesting to note that the speech as originally written used the term *military-industrial-congressional complex*, but Eisenhower dropped the reference to Congress at the last minute. By implicating Congress, he was pointing to the reigning corruption of the legislative process: the lobbying, the enactment of laws and the appropriation of funds for the enrichment of private corporations, and the revolving door through which businessmen achieve public office, create laws and policies beneficial to their industries and then return

to the private sector. By this process, government is transformed into the servant of private interests.

The Cult of Nuclearists is comprised of people of a common mentality. They embrace nuclear and radiological weapons as a reasonable element of warcraft and statecraft and are responsible for maintaining these weapons in our midst. They have never made a serious effort to forge an international consensus to banish nuclear weapons. They venerate the power they wield, the threat they project, the advantage they possess over the less powerful. They have created a world that 99.999% of humanity abhor. Worldwide, this group of people is relatively small, perhaps numbering in the tens of thousands, and yet they manage to hold six and a half billion people hostage to their agenda. Due to their small number, it is befitting to characterize their behavior as cultish. The Cult of Nuclearists is ideologically committed to perpetuating their instruments of devastation. They harbor a mentality in which the threat of mass destruction serves a useful purpose. They champion the credo that nuclear weapons maintain national security and international stability and that an enduring peace is achievable through deterrence strategy and the threat of Mutually Assured Destruction. Perhaps, most importantly, they capitalize on the menace of nuclear weapons to achieve, in peacetime, political objectives.

Acts of genocide and genocidal intent are born from ideology. This is the conclusion of Robert Jay Lifton and Eric Markusen in their book *The Genocidal Mentality: Nazi Holocaust and Nuclear Threat.* According to the authors, the ideology of genocide, whether formulated by a single human being or a contingent of like-minded individuals, embodies "*the psychological characteristics of a particular group of people centrally involved with significant historical forces of their era*." This core group of individuals with their shared psychology promulgates the ideology in expanding circles of influence. Adopted by politicians, the military, the monied interests, it metamorphoses into national policy. As Lifton and Markusen observe, the "genocidal mentality can become bound up with the institutional arrangements necessary for the genocidal act." Under these circumstances, the problem of the perpetuation of nuclear weapons seems intractable. But hidden behind the vast bureaucracy that builds and maintains nuclear weapons are a handful of decision-makers responsible for perpetuating them.

The subject of this book is the Cult of Nuclearists in the United States. But membership in this fraternity is worldwide, existing among all the nations possessing or aspiring to possess nuclear weapons. It is their shared mentality which is the enemy of humankind and a threat to life on Earth. They have all produced monumental crimes against the environment and sickened innocent populations with nuclear pollution. And all hide the consequences of their deeds behind the same pack of lies which are dissected within these

pages. There exists no greater threat to the common good than that schemers and deceivers control nuclear and radiological weapons.

Nuclear weapons have despotically imposed a new order on human affairs. At the time of Hiroshima and Nagasaki, people everywhere welcomed the cessation of fighting with joyful hearts. But simultaneously, the realization began to dawn that a more enduring horror had been visited upon the earth. With no discussion and no consensus on a matter that impacted every living soul, nuclear weapons became ubiquitous on the landscape. The arms race was a theater of terror, subduing the hope of an entire planet for peace and love and fellowship. The open display of infernal destructiveness victimized us all. And it had its intended effect. Human beings have been subjugated by the fear of nuclear holocaust. The interior landscape of each one of us has been conquered by a sense of powerlessness. We have been robbed of the belief in our freedom, that we can control our own destiny and protect that which we hold dear. In galling humiliation, we have been turned into victims-in-waiting. Our well-being is at the mercy of those with a genocidal mentality. In violation of our sensibilities and sense of decency, we have been forced to live our lives inextricably entangled in the intrigues of petty potentates who derive their right to dictate affairs from the brutality of the weapons they wield. The people of the earth have unfinished business with the Cult of Nuclearists.

3

The Mettle of the Metal

Depleted uranium did not exist on Earth prior to the Manhattan Project. Its birth was an inconvenience, spawned by visions of controlled devastation and unrestrained heartbreak. To incinerate a city in a single blast, a few dozen pounds of a novel species of uranium was required, one that consisted by mass of approximately 90 percent uranium-235. Nature was not accommodating to this enterprise. The uranium found in nature, once extracted from the earth, purified and concentrated, has a mass content of only 0.7 percent uranium-235. To achieve higher concentrations of the isotope, technological wizardry was conjured, wizardry that would have stunned a medieval alchemist. Methods of isotope separation were developed which concentrated, atom by atom, a portion of the uranium-235 content of natural uranium from the vastly more abundant uranium-238. Flowing out from the process were two streams. One was "enriched" uranium, a designer product that could be fashioned with any concentration of uranium-235 to fuel either controlled chain reactions in nuclear reactors or uncontrolled chain reactions in city-destroying bursts of energy . The other stream was "depleted" uranium, natural uranium diminished by a few tenths of one percent of its uranium-235 content.

In the six decades since the Manhattan Project, the United States and other countries with enrichment capabilities have stockpiled a huge inventory of DU. For every kilogram of weapons-grade uranium created, 200 kilograms of depleted uranium were deposited in storage containers located nearby to enrichment facilities. Another five to 10 kilograms of DU were produced for each kilogram of low-enriched uranium destined to fuel nuclear reactors (Alvarez 2003). By the turn of the century, the United States was in possession of 732,000 metric tons of depleted uranium (Alvarez 2003). This is just over half of the world's total inventory.

This ever-growing cache of DU stimulated thinking as to how it could be utilized commercially. For some applications, metallic DU is an attractive material. This is due primarily to its high density. At room temperature, unalloyed uranium has a density of 19.05 grams per cubic centimeter. This makes it 1.7 times more dense than lead (11.35 g/cm^3) and nearly as dense as tungsten (19.25 g/cm^3). From a metallurgical viewpoint, DU is much easier to fabricate than many other dense metals. It is malleable and ductile, and it exhibits relatively good mechanical properties. DU's attractiveness is further enhanced by the fact that it is abundant and cheap.

There are a number of minor applications to which uranium has been put that are of historical interest. These are succinctly enumerated in the internet encyclopedia, Wikipedia:

> Prior to the discovery of radiation, uranium was primarily used in small amounts for yellow glass and pottery dyes (such as uranium glass and in Fiestaware). Uranium was also used in photographic chemicals (especially uranium nitrate as a toner), in lamp filaments, to improve the appearance of dentures, and in the leather and wood industries for stains and dyes. Uranium salts are mordants of silk or wool. Uranyl acetate and uranyl formate are used as stains in transmission electron microscopy, to increase the contrast of biological specimens in ultrathin sections and in negative staining of viruses, isolated cell organelles and macromolecules.

Due to its high atomic number, Z=92, and great density, depleted uranium is frequently used as a shield for absorbing gamma radiation. These properties allow such shields to be thinner than those made of other materials with a comparable absorption capacity. Spent fuel elements from nuclear reactors are frequently transported in casks fabricated from DU. Similarly, the radiopharmaceuticals and radioisotopes used in research and industrial applications are shipped in containers lined with DU. Walls or barriers made of DU can be found in the x-ray and radiation therapy departments of hospitals for protecting medical staff. The radiation source in some medical therapy machines is housed in a DU enclosure to prevent stray emissions. Retractable DU shields can often be found in portable industrial radiographic equipment. At large irradiation facilities used for such purposes as sterilizing medical equipment or killing food-borne microorganisms in foodstuffs, the radiation source is remotely removed from its DU enclosure after humans have safely vacated the exposure chamber.

In applications where great weight is required but size is a limiting factor, uranium is a suitable material. This is the rationale for the use of DU in aeronautics. To maintain

their center of gravity while in flight, airplanes have been built with DU counterbalance weights incorporated into their aerodynamic control devices. Some wide-body aircraft were originally fitted with rudders, ailerons and elevators fabricated with DU. Each Boeing 747 coming off the assembly line between 1968 and 1981 contained between 850 and 1,500 kg of uranium counterweights (Loewenstein; WISE 2002). Airline manufacturers began phasing out DU during the 1980s, designing new airplanes and retrofitting old ones with counterweights made of tungsten. Nevertheless, older aircraft still fitted with DU remain in operation, though their exact number is not readily available. In addition to airplanes, helicopters at one time were built with DU incorporated into their designs. Prior to 1979, Boeing weighted the tip of rotor blades with between one and three 0.22 kg triangular DU weights (WISE 2002). The blades of all such helicopters have since been replaced with composite blades containing no DU. Another aeronautical application for depleted uranium has been its inclusion in missiles and satellites as ballast to create in-flight stability.

DU has been put to a number of other uses. Neutron detectors frequently contain the metal. It has been employed as a chemical catalyst. Counterbalancing weights of DU have been fitted to radar antenna. Special high-performance gyroscope rotors have been fabricated from DU and the metal has been used for dampening vibrations in machinery, flywheels and boring bars. In *DUF_6 Materials Use Roadmap* (Haire and Croff), commercial applications were proposed for a portion of the stockpiled DU that included combining DU with other chemicals to manufacture various catalysts which in turn could be used in petroleum refining, chemical processing and in the catalytic converters of automobiles. Such catalysts might also be used to produce hydrogen in fuel cells or from steam. Other suggested applications for DU include its incorporation into electrodes for refining aluminum from ores, as counterweights under heavy-lifting equipment and as a component in locomotive wheels. Yet the *Roadmap* is unambiguous and categorical in its assessment that all commercial applications would need to be followed by the eventual disposal of all DU-containing materials in low-level waste repositories.

There are a number of current or proposed applications for DU within the nuclear industry. As part of the process of arms reduction, weapon-grade highly enriched uranium is being downblended with DU to create fuel for commercial light-water reactors. A mixed oxide (MOX) fuel is also being created through a blending of DU with plutonium oxide derived from decommissioned nuclear weapons. In Russia, DU is being re-enriched to form a product resembling natural uranium. As a permanent disposal solution for plutonium, a plan has been proposed to blend DU dioxide with plutonium dioxide to produce a ceramic resistant to decomposition so as to lock up the material for centuries. In a similar vein, the need to dispose of the vast inventory of DU while preventing it from leaching into the environment has led to the plan of combining it with cement to make a high-den-

sity concrete. This material, under such trade names as Cement-Lock and DUCRETE, could be used to form products such as spent fuel storage silos or casks to permanently store certain types of radioactive waste. Underground waste repositories could be built or reinforced with this material as well. Regardless of use, all aboveground applications of DU-containing concrete would eventually require the material to be broken up and transported to a low-level waste repository for permanent burial. DUPoly is another novel material that can be produced by mixing DU oxide with molten polyethylene to form a high-density polyethylene.

Obvious drawbacks exist in all plans to incorporate DU into commercial products. The most prominent is that no mechanism for oversight exists to keep track of the use, recycling and eventual disposal of the material. Invariably, this failing will lead to mistakes, resulting in unnecessary radiation and heavy metal exposure. By way of example, there have been instances where DU metals from abandoned medical equipment have ended up in scrap yards, been melted down with other metals and resold. This type of incident creates a vector for the unmonitored migration of radioactive material into the human domain. According to the article "Depleted Uranium On Scrap Heaps" which appeared in the *Guardian Unlimited* on October 31, 2007, fifty tonnes of discarded DU is lying unmonitored in scrap heaps across Britain (Bowers and Brown). This material was originally used in aircraft components and radiotherapy devices. According to the private company applying for salvage rights, the abandonment of this material poses "a growing risk of loss of control, personnel exposure and contamination of the environment." Also mentioned in the article was the fact that the company MSC, now owned by British Nuclear Fuels, had, since 1985, recycled 2,700 tons of DU into more than 70,000 products.

The incorporation of depleted uranium into US military combat systems evolved during the second half of the twentieth century. Following the Korean War, research into the development of new alloys was initiated for the purpose of replacing high-carbon steel in armor-piercing projectiles. To defeat Soviet armored vehicles of the day, tungsten carbide became the new metal of choice in the late 1950s due to its higher density (13 g/cm^3) and superior performance. However, by the early 1960s, tanks with double- and triple-layered armored plating began rolling off Soviet assembly lines. Tungsten carbide was unreliable against these vehicles due to its tendency to break up prior to successfully penetrating the armor. In response, new tungsten alloys were sought with superior penetration capabilities. Throughout the 1960s and early 1970s, a continually improved series of 105 mm cartridges were developed for the cannons of the US M-60 and XM-1 tanks. These cartridges were fabricated from 97.5% tungsten combined with 2.5% of a binder alloy and possessed a density of 18.5 g/cm^3 (Rostker). These rounds were adequate for their day, but forward thinkers continued to research new alloys including ones incorporating depleted uranium.

This research by the Army coincided with testing by the Air Force and Navy of small-caliber DU ammunition (20 mm, 25 mm, 30 mm) which confirmed DU's superior penetrating ability (Rostker). In 1973, after extensive testing, the Army fielded a 105 mm cartridge consisting, by weight, of 99.25% depleted uranium and 0.75% titanium (U-3/4Ti). This alloy overcame earlier limitations in experimental DU projectiles, for it allowed the DU penetrator, essentially a pointed spearlike shaft approximately two feet in length, to withstand the extreme firing velocities of the large caliber cannon without breaking up (Rostker).

Against enemy armored vehicles, the new DU penetrators were superweapons. Since their introduction, no material has yet been fielded that can stop them. Their density is nearly twice that of steel. As they impact a target, their high momentum and kinetic energy is delivered to a very small volume of armor. This enables them to cut through the wall of a tank like butter. Also, unlike the tungsten shells which flatten on impact into a mushroom shape, DU rounds actually self-sharpen as they deform in a process known as "adiabatic shear banding." Fragments of metal break off from the body of the penetrator as it passes through a target in such a manner that it preserves its shape (Hambling). In addition to self-sharpening, uranium has the militarily advantageous characteristic of being highly pyrophoric. Even at relatively low velocities of 30 meters per second, uranium spontaneously bursts into flames. The intense heat of these flames easily ignites gasoline or diesel fumes at the moment of impact, setting the targeted vehicle ablaze. Personnel inside the vehicles stand no chance of escaping.

Since DU's initial introduction, all tank rounds produced have been made of DU. The cannons on the M1 and M60 tanks use a 105 mm round which contains approximately four kilograms of DU. A 120 mm round is used in the M1A1 and M1A2 Abrams tanks. This round contains roughly five kilograms of DU. The M2/3 Bradley Fighting Vehicle uses a 25 mm DU kinetic cartridge in the BUSHMASTER cannon. The Marine AV-8 Harrier aircraft uses a 25 mm round in the GAU-12 Gatling gun. The GPU-30 gun, which shoots a 30 mm DU round, can be mounted on an F16 airplane and used in close air support. Both the 25 mm and 30 mm rounds contain about 0.3 kg of DU each. During the 1970s, the Air Force developed the eight-barreled 30 mm GAU-8/A air-to-surface Gatling gun and specifically designed the A-10 close air-support aircraft around this weapon so that DU ammunition could be effectively directed against the top armor of enemy tanks (Rostker). In parallel with this development, the Navy designed and built the Phalanx Close-In Weapon System to defend against incoming sea-skimming missiles. The 20 mm rounds of this system used an alloy of 98% DU and 2 % molybdenum (Rostker). Starting in 1989, the Navy phased out this round in favor of one made of tungsten, but a large inventory of DU rounds still remain in the Navy's arsenal. In addition to these weapon

systems, the Army has experimented with DU in rifle ammunition of 5.56 mm, 7.62 mm and 50 calibers respectively. Also, small quantities of a DU epoxy catalyst are used in two antipersonnel mines, the M86 Pursuit Deterrent Munition and the Area Denial Artillery Munition (Rostker). It should further be mentioned that one layer of armor in the multi-layered Heavy Armor M1A1 tank is made from DU.

All of the above munitions fall into the category of kinetic-energy penetrators. They are solid projectiles, fired from a gun, that rely upon their high-velocity impact to penetrate and destroy their target (Sandstrom). It is not well known that a second class of penetrators exists: chemical-energy penetrators. In "Armor anti-Armor Materials by Design", Sandstrom describes these weapons as follows:

> This weapon defeats armor by using the chemical energy of a shaped explosive charge, ignited on impact, to propel a metal liner at the target. Typically, the liner is a conical shell bonded to a machined hollow in the charge opposite the detonator with the base of the cone pointing outward toward the target. The shape of the charge focuses much of its explosive force onto the metal liner, turning it inside out and stretching it to form a long jet of solid material. (In other versions of the weapon, a compact, high velocity slug is formed). In effect, the liner becomes a kinetic-energy penetrator but with typical impact velocities of about 7 kilometers per second compared to 1 or 2 kilometers per second for normal kinetic-energy penetrators. Although a kinetic-energy penetrator travels from gun to target at high velocity, a chemical-energy weapon can work even if the device is simply placed against the armor and ignited.

This is an interesting admission for Los Alamos National Laboratory to make because it demonstrates the little-known fact that DU is present in some types of high-explosive munitions. When the high explosive detonates, it invariably vaporizes a portion of the DU, likely creating aerosolization fractions of respirable particles much greater than those reported for kinetic-energy penetrators. This drastically alters contamination dynamics, invalidating many previous studies on how much of an inhalation hazard is produced by DU weapons.

Since the 1991 Gulf War, the US has openly admitted to using DU only in the weapon systems mentioned above. However, the unmistakable signature of nonnaturally occurring species of uranium has been detected in environmental samples gathered at sites bombed by the US in Afghanistan and Iraq and in Lebanon after the bombing by Israel in 2006. This evidence clearly bears witness that DU is being employed in an undisclosed

number of much larger weapons. In fact, research conducted by Dai Williams (2002b) indicated that approximately 23 types of weapons, including bunker-busting smart bombs and cruise missiles, may contain from 25 to 4,400 pounds of DU. In addition, the Big Blu bunker buster bomb contains 6,000 pounds of high explosives and an additional 24,000 pounds of some other unidentified metal which many suspect as being DU. It must be emphasized that these weapons are not passive penetrators. They contain various quantities of explosives. Detonation will aerosolize a large fraction of the DU, creating vast quantities of respirable material that will travel on the winds and into the lungs of unsuspecting downwinders.

The Department of Defense staunchly maintains that the radioactivity of depleted uranium played no part in its selection as a material for making weapons. This stance implies that the sickening of bystanders from the inhalation of radioactive aerosols is an unintended consequence of using DU to destroy enemy armor and hardened targets. Since radioactivity is a fundamental property of uranium, it is difficult to fathom how the metal could be used without taking into account its radiological effects. If the military deploys DU weapons, oblivious of their radioactivity, then at the very least it is guilty of committing crimes of reckless endangerment. This offense is explained in Article 134 of the Uniform Code of Military Justice:

> "Reckless" conduct is conduct that exhibits a culpable disregard of foreseeable consequences to others from the act or omission involved. The accused need not intentionally cause a resulting harm or know that his conduct is substantially certain to cause that result. The ultimate question is whether, under all the circumstances, the accused's conduct was of that heedless nature that made it actually or imminently dangerous to the rights or safety of others.

A wealth of material exists in the public domain testifying to the fact that the military was well aware of the health consequences of inhaling DU prior to the introduction of these weapons into combat, but that it chose to ignore them. And with each new military campaign, it continues to ignore them. A few quotations from publications written prior to the First Gulf War are sufficient to illustrate that it was common knowledge that the inhalation of DU was known to be hazardous.

"In combat situations involving the widespread use of DU munitions, the potential for inhalation, ingestion, or implantation of DU compounds may be locally significant." From Fahey (1998) quoting: *Medical and Environmental Evaluation of Depleted Uranium*. Ad Hoc Working Group on Depleted Uranium of the Joint Technical Coordinating Group for Munitions Effectiveness. April, 1974; p. ix.

"A self-contained breathing apparatus, gas mask, or at least fine-particulate mask should be used whenever airborne alpha radiation is present." "Ionizing Radiations and Their Interactions with Matter" by J.A. Sholtis, Jr. In *Military Radiobiology*. San Diego: Academic Press Inc.; 1987.

"Aerosol DU exposures to soldiers on the battlefield could be significant with potential radiological and toxicological effects. These health impacts may be impossible to reliably quantify even with additional detailed studies. It is not our intention to overstate this issue given other combat risks, nor to imply that the health of soldiers will definitely be compromised. We are simply highlighting the potential for levels of exposure to military personnel during combat that would be unacceptable during peacetime conditions. " From Fahey (1998) quoting: *Kinetic Energy Penetrator Environmental and Health Considerations*. Science Applications International Corporation (SAIC). July 1990; Vol. 1, 4-5.

"Under combat conditions, the MEI's [most exposed individuals] are probably the ground troops that re-enter a battlefield following the exchange of armor-piercing munitions, either on foot or motorized transports." From Fahey (1998) quoting: *Kinetic Energy Penetrator Environmental and Health Considerations*. SAIC. July 1990; Vol. 2, 3-4.

"Personnel in or near (less than approximately 50 meters) an armored vehicle at the time these vehicles were struck by depleted uranium munitions could receive significant internal DU exposures (i.e. those in excess of allowable standards)." Statement of Col. Eric Daxon, Radiation Protection Staff Officer. US Army Medical Command, summarizing the results of a December 1989 report from the Ballistic Research Laboratory: *Radiological Contamination From Impacted Abrams Heavy Armor*. Filszar *et al.* Col. Daxon's statement was made in a July 19, 1996 letter to Dan Fahey, Swords to Plowshares. (Fahey, Selected Quotes)

"Following combat, however, the condition of the battlefield, and the long-term health risks to natives and combat veterans may become issues in the acceptability of the continued use of DU kinetic energy penetrators for military applications." From Fahey (1998) quoting: *Kinetic Energy Penetrator Environmental and Health Considerations*. SAIC. July 1990; Vol. 2, 3-4.

"Assuming US regulatory standards and health physics practices are followed, it is likely that some form of remedial action will be required in a DU post-combat environment." From Fahey (1998) quoting: *Kinetic Energy Penetrator Environmental and Health Considerations*. SAIC. July 1990; Vol. 1, 4-6.

"Our conclusions regarding the health and environmental acceptability of DU penetrators assume both controlled use and the presence of excellent health physics management practices. Combat conditions will lead to the uncontrolled release of DU. Individuals consulted have generally responded to this issue by saying it is irrelevant, or insignificant compared to the other risks of combat. However, environmental issues will arise if DU is used in combat." From Fahey (Selected Quotes) quoting: *Kinetic Energy Penetrator Environmental and Health Considerations*. SAIC. July 1990; Vol. 1, 4-5.

No precise figures exist in the public domain as to how much DU has been dispensed by the United States in recent conflicts. The following figures come from "Depleted Uranium Munitions: Nuclear Waste as a Weapon", published by the Military Toxics Project. During the 1991 Operation Desert Storm in Iraq and Kuwait, US and British Tanks and US aircraft fired roughly 850,000 small caliber DU rounds and 9,600 large caliber shells, totaling 286,000 kg of DU. During NATO operations in Bosnia and Herzegovina in 1994-1995, US A-10 aircraft fired 10,800 rounds containing 3,260 kg of DU. In 1999, in Kosovo, 31,300 rounds were fired from A-10 aircraft depositing 9,450 kg of DU in the countryside. Increasing secrecy on the battlefield has kept pace with mounting worldwide opposition to DU weaponry. The amount of DU expended in Afghanistan between 2001 and 2003, and during the most recent Iraq war which commenced in 2003, is simply not known.

With abandon, the US military disperses depleted uranium into the environment. In addition to the battlefields of our most recent enemies, DU munitions have been test fired at a number of proving grounds and gunnery ranges across the United States. Between 1969 and 1988, 386,100 kg of DU were known to have been fired at the following locations: Ethan Allen Firing Range (Vermont), Lake City Ammunition Plant (Missouri), China Lake Naval Air Warfare Center (California), Yuma Proving Ground (Arizona), New Mexico Institute of Mining and Technology, Los Alamos National Laboratory (New Mexico), Jefferson Proving Ground (Indiana), Aberdeen Proving Ground (Maryland), Elgin Air Force Base (Florida) and Nellis Air Force Base (Nevada) [van der Keur; Military Toxics Project]. In addition, DU munitions were test-fired in 1995-1996 near the island of Okinawa, without the permission or knowledge of the Japanese government, and in 1999 at Vieques Island, Puerto Rico. In January 2003, the Navy made known that, since 1977, it had routinely fired DU munitions from Phalanx gun systems into prime fishing waters off the coast of Washington (Military Toxics Project). This example has not been lost on other nations. The Taiwanese Navy has fired 60,000 DU rounds during military maneuvers in recent years (van der Kuer). The British Army has also acknowledged firing DU ammunition at test sites near Eskmeals and Kirkcudbright and since 1982 has

fired 6,000 120 mm rounds into the Scottish Solway Firth, close to the village of Dundrennan (van der Kuer).

"No international law, treaty, regulation, or custom requires the United States to remediate Persian Gulf War battlefields." This statement was published by the US Army Environmental Policy Institute in 1995 (USAEPI). To date, it appears to be an expression of government policy.[1] Financially, it has to be. Cleanup of battlefields and gunnery ranges is prohibitively expensive. Not only must shell fragments and unspent shells be collected, but due to the widespread scattering of microscopic particles of aerosolized uranium, the topsoil must be scraped off, collected and disposed of. This creates it own problems, for the process facilitates erosion and the possible migration of remaining uranium to clean areas. As an alternative, eye witnesses report battlefields in Iraq being covered over by fill, perhaps to hide combat areas where DU shells were expended or to attempt to trap the contamination locally and prevent its scattering by the winds. As an example of the potentially high costs of remediation, cleanup of the 152,000 pounds of DU scattered over 500 acres of the Jefferson Proving Ground in Indiana is estimated to have been between $4 and $5 billion (Fahey 1998).

To date, the use by the United States of DU weapons is but the opening salvo in radiological warfare. A number of other countries are in possession of weapons containing depleted uranium. According to the US Army Environmental Policy Institute, countries which have developed or are currently developing DU-containing weapon systems include the United Kingdom, Russia, Turkey, Saudi Arabia, Pakistan, Thailand, Israel and France (Schott et al). Furthering the spread of these weapons is the fact that they are openly sold in the world arms market. The United States has significantly contributed to the proliferation of depleted uranium weapons by selling DU to a number of other countries. This was made possible by the US International Security and Development Cooperation Act of 1980 which contains the following provision:

> Upon a finding that an export of uranium depleted in the isotope 235 is incorporated in defense articles or commodities solely to take

[1] One known exception was reported in April 2008 (Olson). Sand contaminated with depleted uranium and lead was brought to the United States from camp Doha, an Army base in Kuwait. The 6,700 tons were shipped in 306 containers and were offloaded onto railroad cars at the Port of Longview on the Columbia River. The contaminated material was then transported to a disposal site in Idaho. Longshoremen were reported to have worn standard safety gear and dust protection equipment but declined the use of respirators. The operation was managed by the disposal company American Ecology.

> advantage of the high density or pyrophoric characteristics unrelated to its radioactivity, such export shall be exempt from the provisions of the Atomic Energy Act of 1954 (42 USC. 2001 et seq.) and of the Nuclear Non-Proliferation Act of 1978 (22 USC. 3201 et seq.) when such exports are subject to the controls established under the Arms Export Control Act (22 USC. 2751 et seq.) or the Export Administration Act of 1979 (50 App. USC. 2401 et seq.) (Schott *et al.*).

An article appearing in *Defense Trade News* in 1992 reported that US legislation made it permissible to sell antitank shells containing DU penetrators or the individual penetrators themselves to NATO countries which included Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Turkey and the UK. Non-NATO allies also eligible to receive DU munitions were Australia, Egypt, Israel, Japan, Korea and Taiwan (Schott *et al.*). The 1994 Export Financing and Related Programs Appropriation Act signed by President Bill Clinton specifically mentioned that the security interests of the United States dictated that funds be made available to facilitate the sale of certain depleted uranium munitions to Bahrain, Saudi Arabia and Kuwait. It is also known that the US has supplied Oman with DU weaponry (ICBUW). Other countries so armed include China, India and Jordan (ICBUW).

The current inventory of depleted uranium in the United States is approximately 732,000 metric tonnes, roughly equivalent to 1,600,000,000 pounds. This quantity is equivalent in weight to seventy Ticonderoga-class Navy cruisers or eight Nimitz-class aircraft carriers (Military Toxics Project). This DU is stored at a number of sites throughout the US and exists in a number of chemical and physical configurations as indicated in the table below (Makhijani, Chalmers and Smith, October 2004; Alvarez 2003).

Form	**Quantity (metric tonnes)**
UF_6 (uranium hexafluoride)	704,000
UO_3 (uranium trioxide)	19,700
Metal	5,300
UF_4 (uranium tetrafluoride)	3,000
Other Oxides	145
Miscellaneous and Scrap	35

Depleted uranium leaves the enrichment process in the form of uranium hexafluoride. Currently, this material is stored in 57,122 storage cylinders on the sites of the three uranium enrichment plants in respectively, Oak Ridge, Tennessee, Paducah, Kentucky and Portsmouth, Ohio. Each cylinder is initially filled to 95% capacity with liquid UF_6. As this cools it contracts and forms a crystalline solid. When cooling is complete, each 12.7 ton container is filled to 60 percent with the UF_6 in solid form and the rest remains as a gas. Outside storage in metal cylinders is only a stopgap storage solution. UF_6 is highly corrosive to metals, and the anticipated life of the storage cylinders is just a matter of decades. Leaks have occurred in at least 10 cylinders to date, creating a hazardous situation. Exposed to the moisture in air, UF_6 is transformed into UO_2F_2 (uranyl fluoride) and HF (hydrogen fluoride), both of which are highly toxic. Compounding the hazard, much of the uranium hexafluoride is contaminated with plutonium and other transuranic elements (Military Toxics Project).

Currently, uranium/depleted uranium is classified as a source material. A heated debate, however, is quietly being waged as to how it should be classified at the time of final disposal. In circumstances where DU might be discarded as waste, the Nuclear Regulatory Commission considers it as falling within the category of class A low-level radioactive waste. This classification allows for near-surface burial. Arjun Makhijani and colleagues at the Institute for Energy and Environmental Research have convincingly argued that, for the purposes of waste management and disposal, DU is mostly closely comparable to transuranic waste (Makhijani and Makhijani; Makhijani and Smith). This designation would mandate deep geologic burial. Their argument goes something like this: Transuranic wastes consist generally of inhomogeneous materials containing trace quantities of such transuranic radionuclides as neptunium-237, plutonium-238, plutonium-239, plutonium-240 and americium-241. According to the Code of Federal Regulations, section 40 CFR 191.01 (i), transuranic waste is "waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes, with half-lives greater than 20 years, per gram of waste." A curie is a unit of measure of radioactivity. It is based on the rate of decay of one gram of radium-226 and is equivalent to 37 billion disintegrations (now termed becquerels) per second. Consequently, one nanocurie represents one-billionth of a curie or 37 disintegrations per second. Thus, by definition, transuranic waste is waste that at a minimum has more than 3,700 disintegrations per second per gram of material. By contrast, DU metal is a pure material. Although its specific activity (the number of disintegrations per gram) can vary depending on the degree of depletion of uranium-235, at minimum it is 360 nanocuries (Makhijani and Makhijani). This is equivalent to 13,320 disintegrations per second!

In addition to their specific activities, DU and transuranics share other similarities.

All three isotopes in naturally occurring uranium undergo radioactive decay by emitting an alpha particle from their nuclei. The energy carried by these alpha particles ranges from 4.1 to 4.8 MeV (million electron-volts). For the transuranics mentioned above, all likewise undergo alpha decay with energies ranging from 4.8 to 5.5 MeV. To quote the authors:

> What matters to health and environmental considerations is the specific activity of the radioactive wastes, the nature of the radiation being emitted during the radioactive decay (alpha or beta and whether the decay is accompanied by gamma radiation) and the energy per radioactive decay. Depleted uranium is, in these essential respects, the same as the transuranic constituents of TRU waste. The specific ways in which uranium or the transuranic radionuclides in TRU waste might affect people will, of course, depend on the chemical form of the waste, the packaging, and the disposal method (Makhijani and Makhijani).

It is important to note that this argument is not meant to imply that a gram of depleted uranium is more dangerous than a gram of a transuranic radionuclide such as plutonium-238. Pu-238 has a specific activity of 640,100,000,000 disintegrations per second. Obviously, it is vastly more hazardous. The point of the argument, comparing equivalent volumes of transuranic wastes and DU, is that clear-thinking regulators at one time recognized the hazard to health of low levels of inhomogeneous transuranic wastes and mandated burial in a deep geologic repository. In contrast, DU, which is approximately 3.6 times more radioactive than the minimum activity of these wastes recommended for burial, are being cavalierly scattered over other peoples' homelands.

4

A Primer in the Art of Deception

Those who can make you believe absurdities can make you commit atrocities.
Voltaire

To sustain the lie that uranium weapons pose no hazard to health, an artful repertoire of falsehood and deceit has been crafted. Half-truths, distortions, fabrications, fallacious reasoning: these are the stock-in-trade of the government and military spokesmen "educating" the public on issues of uranium munitions and radiation safety. At every opportunity, these conjurers chant the same litany of misinformation into the ears of the public, casting a spell on their intellects and charming them into believing as true what is blatantly false.

The phenomenon of propaganda can be understood. It is an instrument of coercion that government employs to persuade the governed to accept its deeds. The ignorance of the average person on issues of radiation physics can also be understood. Our educational system fails to equip students with the knowledge they need to be conversant with current issues of national policy. High school graduates, as a rule, have little or no knowledge of basic nuclear physics, and those going on to college gain no exposure to this topic unless they major in one of the sciences. But what cannot be understood, what goes beyond all comprehension, is why trained professionals who are sufficiently educated to see through the misstatements of government keep their lips sealed and allow lies and ignorance to prevail.

Their situation is no different from that of the doctors in Nazi Germany who knew of the human experiments, the euthanasia, the death camps — and did nothing. Those who have knowledge but remain silent are accomplices to those shepherding radiological warfare into the world and are just as equally responsible as the government for the chronic illnesses and birth defects that are being caused.

The contention that uranium weapons do not pose a radiological hazard is a house of cards propped up by a number of false notions issued by government, the military and their sympathizers that bamboozle those who question the wisdom of scattering radioactivity over the face of the earth. What follows is a primer on these foundational lies.

Depleted uranium is less hazardous than natural uranium because it is "depleted." It is 40% less radioactive than natural uranium.

This statement, so apparently straightforward, is a minefield. The problem lies with the words "natural uranium." Until definitions are unambiguous and everyone shares the same understanding as to what "natural uranium" denotes, clarity as to the true hazard of depleted uranium can never be achieved.

It often comes as a surprise to people to discover that the expression *natural uranium* is in reality a specialized, technical term. Used precisely, it refers to uranium that has been mined, crushed, concentrated, and then chemically stripped of all other minerals. This purified material is 100% uranium and is composed of three isotopes: uranium-238, uranium-235 and uranium-234. In contrast to this specialized product, there is the *uranium found in nature*. This expression is coined here for purposes of clarity and will be used to refer to the uranium that is ubiquitously found amidst rocks and soil on the Earth's surface. This uranium consists of the same three uranium isotopes in the same proportions as that found in natural uranium. However, the *uranium found in nature* is never found in as concentrated a form as so-called *natural uranium*. The term *depleted uranium*, as originally coined, is meant to designate what remains of *natural uranium* after a portion of its uranium-235 content has been extracted for the production of nuclear weapons and the fuel for nuclear reactors.

Since the advent of uranium munitions, a web of words has been spun to misinform the public. The difference between *natural uranium* and *uranium found in nature* has been obfuscated so that people are misled into believing that depleted uranium is less hazardous than the uranium found in nature. This is a totally false notion. Depleted uranium incorporated into the interior of the body poses a far greater threat to health than does the incorporation into the body of the uranium found in nature.

As residents on planet earth, all human beings have the uranium found in nature continually cycling through their bodies. In rocks and soils, uranium found in nature exists in concentrations of between 0.5 and 5 parts per million with the average in most soils being 1.8 ppm. This works out to approximately 2-3 grams of uranium within each metric ton. In minute concentrations, uranium is present in the food we eat, the water we drink, the air which we breathe. There is no known physiological need for this uranium in the body. It is biologically inessential. At any one time, the average human body contains 90 millionths of a gram of uranium. Daily, through our food and water, we ingest 2 millionths of a gram of uranium. Yearly intake is approximately 0.000436 grams. Passing through the digestive system, 98% is eliminated in the feces. Of the 2% absorbed, 60-70% passes through the bloodstream and is eliminated in urine within 24 hours. Another 10% is deposited in the kidney and excreted relatively rapidly. Its biological half-life is 15 days.[1] Most of the remaining 20% or so is deposited in bone with the remnant distributed to other organs and tissues. Simultaneously, uranium previously deposited in the recesses of our bodies is gradually released from its tissues of retention, enters the circulation, and is eliminated. Human exposure to the uranium found in nature occurs primarily through the gradual uptake over time of extremely diluted concentrations of soluble uranium compounds. This material gradually enters the body, has widespread distribution throughout many organ systems, and is then eliminated. No localized cluster of cells receives a greater dose of radiation than any other cluster. Radioactive decay of the atoms of this uranium presents an infinitely small hazard to the health of the organism as a whole.

Natural uranium — uranium that has been concentrated by human beings — represents an enhanced radiological hazard over the uranium found in nature. Since the 1940s, humankind has unearthed millions of tons of uranium-bearing ore, extracted the uranium and concentrated it. This man-made product is a new radiological pollutant that never before existed on the Earth's surface. Thus, so-called *natural* uranium has only existed in the biosphere since the Manhattan Project. (This obfuscation of the English language is a grand ploy by which the Cult of Nuclearists bewilders and misleads humankind.)

To grasp the radiological difference between depleted uranium and the uranium found in nature, a simple example will suffice. Let's imagine that two spherical particles, each 2.5 microns (0.0001 inch) in diameter, are absorbed into the bloodstream. One is a speck of dust of depleted uranium metal composed of 100% uranium. Mathematically, it has been estimated that such a particle contains approximately 210,000,000,000 molecules of UO_2 (Dietz). The second particle is a speck of soil entering into the body with some

[1] Biological half-life is the amount of time it takes for one-half of a substance to be eliminated from the body.

ingested food. Its uranium content is that of the uranium found in nature. For simplicity's sake, let's assume this speck contains the same number of molecules. If its uranium concentration exists as 1 ppm, it will contain only 210,000 molecules of uranium. Thus, for equivalent quantities of uranium to enter the body, one would have to ingest one million soil particles to uptake the same amount of uranium as that contained in the single particle of DU. Consequently, it should be apparent that micron-sized particles of depleted uranium create a significantly greater localized chemical and radiological hazard to the cells in the immediate vicinity of where they become lodged compared with internalized particles containing the uranium found in nature.

The hazard of depleted uranium can be framed another way. Within each kilogram of soil, 10 to 20 atoms of uranium (all uranium isotopes considered) decay each second. In a kilogram of pure depleted uranium, 12,400,000 atoms of uranium-238 disintegrate each second (Busby 2003). After the war in Kosovo where depleted uranium munitions were fired, soil samples analyzed by the United Nations Environment Program revealed uranium activity of 250,000 disintegrations per second per kilogram of soil (UNEP).

Typically, uranium-bearing ore contains between 0.1% and 0.2% uranium, although under rare circumstances it can reach as high as 10% or more. Commonly, a ton of ore yields between two and four pounds of uranium. This uranium exists in many different chemical forms. The most common form is U_3O_8, triuranium octaoxide, which is a crystalline blend of UO_2 and UO_3 in a ratio of 1:2. Incorporated in the ore are the 14 radioactive isotopes formed through the decay series of uranium-238, one of which is uranium-234, and the 11 radioactive isotopes from the decay series of uranium-235. All of these are in secular equilibrium with their parent uranium isotope, meaning that they all undergo radioactive decay at the same rate. Once mined, the ore is put through a milling process. At this point the ore undergoes crushing and grinding followed by acid or alkaline leaching. Next comes either solvent extraction or passage through ion exchangers followed by precipitation. By the end of this stage, 85% of the decay products of the parent uranium isotopes have been removed. The uranium, now concentrated from 40-85% purity, is in the chemical form U_3O_8 and goes by the name of "yellowcake." As Dr. Rosalie Bertell has observed: "Compared with the uranium found in nature in soil and rock, yellowcake is about 300,000 times more concentrated" (Bertell 2000). (This is in substantial agreement with the example provided above when comparing a particle of depleted uranium with one of uranium found in nature.) From the mill, yellowcake is moved along the uranium fuel cycle to other facilities for further refining. Purification at this stage involves either digestion with nitric acid followed by extraction of the uranyl nitrate or conversion to UF_6 followed by fractional distillation At the completion of this step, all progeny radioisotopes from uranium-238 and uranium-235, with the exception of uranium-234, have been

removed and the uranium is chemically pure. This purified uranium product is what is known as “natural” uranium. Natural uranium is pure uranium consisting exclusively of the three uranium isotopes found in nature. These are all chemically identical and differ only by the number of neutrons in their nuclei. (To minimize confusion, some researchers have begun calling this product “undepleted” or “nondepleted” uranium.) The relative concentrations of the three isotopes as they are found in nature and in a mass of natural uranium is as follows: uranium-238 (99.274%), uranium-235 (0.720%), uranium-234 (0.0055%). As seen in the chart, uranium-234, the least abundant isotope, contributes nearly half of the radioactivity of natural uranium due to its relatively shorter half-life. Uranium-238 with its much longer half-life contributes an equal amount of radioactivity due to its greater abundance. The remaining 2% of the radioactivity comes from the decay of uranium-235.

Radiological Characteristics of the Isotopes Making Up Natural Uranium

Isotope	Half-life (years)	% by mass	% by activity	Activity of each isotope (Bg/g)	Type of radiation emitted	Energy of alpha radiation
U-238	4.5 billion	99.3	49	12,300	alpha	4.2 MeV
U-235	704 million	0.7	2	80,000	alpha gamma	4.5 MeV
U-234	246,000	0.005	49	227 million	alpha	4.8 MeV

Half-life : time after which the radioactivity has reduced by half.
Bq/g: Becquerels/gram. A Becquerel corresponds to one decaying atom per second
MeV: million electron-volts.

Chart reproduced from a publication of the French Atomic Energy Agency (CEA)

In order to sustain a chain reaction by the splitting of the nuclei of uranium atoms, the relative presence of uranium-235 must be increased within a mass of uranium-238.

Reactor-grade uranium requires a relative abundance of 3.2 - 3.6% uranium-235. Weapon-grade uranium requires a relative abundance of uranium-235 of 90% or more. To achieve these concentrations, natural uranium is sent through an enrichment process whereby atoms of uranium-235 are separated from natural uranium and concentrated to form "enriched" uranium to the required concentration. The natural uranium from which uranium-235 has been removed is now "depleted," — from 0.720% of uranium-235 to approximately 0.202% uranium-235. The relative concentrations of the three uranium isotopes in depleted uranium are: uranium-238 (99.797%), uranium-235 (0.202%) and uranium-234 (0.0008%).

Isotopic Composition of Uranium (%)

Uranium	**U-238**	**U-235**	**U-234**
Natural Uranium	99.274	0.720	0.0055
Depleted Uranium	99.797	0.202	0.0008

http://vzajic.tripod.com/1stchapter.html#Natural%20Radioactivity

In the process of separating uranium-235, most of the uranium-234 is also removed. As a consequence, depleted uranium is less radioactive than natural uranium. To compare this difference in radioactivity between natural uranium and depleted uranium, physicists compare their specific activity, i.e., number of disintegrations per second per gram of each material. The specific activity of natural uranium (considering only the alpha emissions from the uranium and ignoring the radioactivity of the decay products) is 0.67 microcuries per gram. This means that in every gram of concentrated natural uranium, 24,790 uranium atoms are undergoing radioactive decay each second. The specific activity of depleted uranium (again ignoring the radioactivity of the daughter products) is 0.4 microcuries per gram. This is equivalent to 14,800 disintegrations each second. Comparing the two, depleted uranium is 40% less radioactive than "natural" uranium.

The rhetorical sleight of hand contained in the term "depleted" uranium can now be understood. Those defending the use of depleted uranium armaments never tire of mentioning the fact that DU is 40% less radioactive than natural uranium. This statement is gobbledygook. It is a playing with words in order to sow confusion. The idea being planted in the mind of the public is that, because it is "depleted", it is less radioactive than the uranium to which we all are constantly being exposed. **BUT THIS IS NOT THE CASE**. It must be recalled that the term "natural uranium" is a technical term referring to

uranium that has been purified, chemically separated and concentrated from yellowcake. When compared to this form of uranium, depleted uranium is in fact 40% less radioactive. But what relevance does this have? The vast majority of people on earth are never exposed to uranium ore, yellowcake or "natural uranium." Only a small number of employees in the nuclear industries are exposed to "natural uranium." The uranium to which the average person is exposed on a daily basis, the ubiquitous uranium in the environment from rocks and soil, is hundreds of thousands of times less concentrated than so-called "natural uranium." In an honest comparison, the radioactivity of depleted uranium must be compared to the radioactivity of the uranium found in nature that enters the human body through dietary intake. When this is done, as in the example provided earlier comparing two 2.5 micron particles, it turns out that depleted uranium is substantially *more* radioactive. To once again quote Dr. Rosalie Bertell, "Depleted uranium is some thousand times more radioactive than natural uranium in its natural state [i.e. the uranium found in nature] in soil and rock" (Bertell 2000).

The truth of the matter is that uranium munitions vastly increase the amount of uranium in the environment in which they are fired. They liberate concentrated particles of uranium which are not normally found in nature. The radiological hazard created by the inhalation and ingestion of this material is substantially greater than that received from the normal dietary intake of uranium. "Depleted" uranium is not depleted when compared to uranium as it is found in nature. It is a concentrated form of uranium that is more radioactive. Human beings who take depleted uranium into their bodies are receiving unnaturally elevated doses of radiation to the cell clusters in the immediate vicinity around which a particle of DU is lodged.

Depleted uranium does not pose a radiological hazard because it emits alpha particles which are so weak that they cannot even penetrate the skin.

The statement that alpha particles are incapable of penetrating the skin is true. Its incessant repetition in government propaganda is to plant the idea in the public mind that the radiation emitted by uranium is too weak to penetrate the body and adversely affect human health. The deceit hidden in this statement is contained in what it leaves unsaid.

The discussion that follows is dedicated to the memory of Dr. Harrison Martland, a pioneer in the study of internal contamination by radionuclides who carried out extensive research on the failing health of the radium dial painters over 70 years ago. In an article published in 1929, he remarked: "*Alpha particles are probably the most potent and destructive agents*

known to science" (Martland).

When an atom of uranium-238 undergoes radioactive decay, it emits an alpha particle from its nucleus. An alpha particle is identical to the nucleus of a helium atom. It consists of two protons and two neutrons bound together. The two protons give this particle two units of positive electrical charge. In contrast, electrons orbiting the nuclei of atoms possess one unit of negative electrical charge. As most people remember from playing with magnets as children, unlike charges attract each other. When an emitted alpha particle courses past atoms in the medium in which it is released, electromagnetic interactions between the particle and orbital electrons are such that the force acting on the electrons is sufficient to propel their escape from the atoms to which they are bound. For purposes of this discussion, an alpha particle can be visualized as a powerful, irresistible magnet, effortlessly dislocating orbital electrons and liberating them.

Imagine an atom of hydrogen. A single electron orbits a nucleus consisting of a single proton. The atom is electrically neutral. The positive charge of the single proton is balanced by the negative charge of the electron. When an alpha particle comes in proximity with this atom, it draws the electron from its orbit around the proton, releasing it into the surrounding medium. Simultaneously, the positively charged proton is liberated from its electron. What has taken place is ionization. An electrically neutral atom has been broken into a pair of oppositely charged particles. Ionization of more complex molecules can also occur. In a molecule consisting of two or more atoms bonded together, the ejection of an orbital electron can sever the bond between atoms creating pairs of oppositely charged particles. The charged particles created by ionization, once liberated into the surrounding medium, go on to ionize other molecules. Ion pairs have an extremely short lifespan, on the order of 10^{-18} to 10^{-16} seconds. They then undergo one of many reactions that lead to the formation of free radicals. When ions and free radicals are produced in a biological medium, they are extremely reactive agents, and they promote chemical chaos in neighboring molecules. On average, the transfer of 34 electron-volts of energy is required to break the chemical bond holding together one of the molecules in our body. A single alpha particle ejected from one uranium atom carries an energy of approximately 4.18 million electron-volts. Thus, one alpha particle has the potential of creating ~123,000 ionizations. In a cascading effect, the charged particles created in these ionizing events go on to initiate millions more ionizations. An alpha particle is a bull in the proverbial china shop. It massively disrupts the chemical integrity of the molecules that constitute a living system. What distinguishes a biological system from lifeless matter is its ordered structure. This ordered structure is the medium in which the exquisite choreography of living processes takes place. Ionizing radiation overwhelms ordered structure and renders it into fragmented chaos

unable to carry out further biological activity. This in turn may manifest as metabolic changes in a cell and may ultimately manifest at the macroscopic level as illness.

To understand fully the destructiveness of an alpha particle, one must visualize what goes on as the alpha particle traverses a biological medium. Ejected from the nucleus of a uranium atom undergoing radioactive decay, a high-energy alpha particle is set in motion. It follows a straight path called a track. Being so effective in causing ionization, ionizing events occur in very close proximity to each other. Alpha particles are said to have high LET or linear energy transfer. They transfer more electron volts per micrometer than any other type of radiation thus creating a dense pattern of ionization along their tracks. In each interaction with an orbital electron, the alpha particle transfers some of its energy and is progressively slowed down. As it slows, the density of ionization actually increases. The alpha particle creates so much breakage and liberates so many electrons in such a minute span that its energy is rapidly dissipated and in no time comes to a complete stop. Binding with liberated electrons, the alpha particle is transformed into an atom of helium. In a biological medium, an alpha particle has a range of between 17 and 30 microns. In other words, an alpha particle will not traverse more than about 3-5 cell diameters. It is within this short range that all the biological damage it has initiated takes place. A massive assault on the chemical integrity of a small population of cells is the end result.

This is the key to the lie about alpha particles. Alpha particles are not **weak**. They do not penetrate the skin to any depth because they are rapidly slowed by all the molecular destruction they are causing. It is their extreme destructiveness that slows them down so rapidly. It is like an invading army which does not invade too far into enemy territory because it expends all its force obliterating the first settlement it comes to.

Now, the *coup de grace*. Government propaganda always frames discussion of alpha particles in terms of their inability to penetrate the skin. But they conveniently omit to mention what happens when alpha particles are emitted within the *interior* of the body. People exposed to uranium munitions inhale uranium into their bodies. Microscopic particles become lodged in the lungs. Some are scavenged into the lymph nodes. Others escape into the systemic circulation. A major site of deposit is in bone, but autopsies of soldiers contaminated by depleted uranium reveal uranium deposited in many different organ systems. These particles lodged within tissue become a point source of ongoing radiation to surrounding cells as individual atoms of uranium decay. Alpha particles are emitted in a spherical volume around an embedded uranium particle, the radius of this sphere being the distance alpha particles are capable of traversing. The number of cells at risk are limited by the range of the alpha particles. Within this sphere, molecular havoc is rampant,

cellular biological damage is created, and the process is ongoing as the individual atoms making up a uranium particle continue to decay over time. Particularly vulnerable are all DNA molecules within the spherical volume around an embedded particle of uranium. Alpha interactions with DNA can cause various kinds of damage such as single-strand breaks, double-strand breaks, base losses, base changes, DNA-DNA crosslinks, and DNA-protein crosslinks. These dramatic alterations in genetic integrity can permanently alter cellular function by causing faulty reproduction of biologically essential molecules. They can also cause genetic damage that is passed on to daughter cells during cell replication. Such mutations can have catastrophic results to the entire organism. The genetic study of cancer cells has determined that all cancers are monoclonal, i.e., a cancer mass consists of the uncontrolled reproduction of a single cell. Even one atom of uranium undergoing alpha decay has the potential for creating a fatal cancer. The type of cancer will depend upon which type of cell is altered.

The nuclear establishment has a long history of intentionally blurring the distinction between external exposure to radioactivity and internal contamination. This gambit has been so successful that after half a century the public has yet to awaken to the danger of low-level radiation released into the environment. The Cult of Nuclearists can survive only in this atmosphere of somnolence. When the public finally awakens to the extreme hazard of internal contamination, it will be outraged.

During the 1950s, when America was testing nuclear weapons in the atmosphere, concern among the population began to grow about the health effects of fallout. To counter this fear, the Atomic Energy Commission intentionally framed news releases about fallout in terms of the hazard posed to the exterior of the human body through irradiation by x-rays and gamma rays. It kept the public in ignorance of the internal hazard posed by the ingestion of contaminated food and water and the inhalation of dust contaminated by radionuclides. This campaign of misinformation was unconscionable. Over the long term, it is internal contamination by radionuclides released into the environment that presents the greater hazard to the health of populations. The intention to confuse the public about the different types of radiation hazard is pervasive even today. Any time there is a release of radiation into the environment, spokesmen for government and industry always frame the discussion for the public in terms of external irradiation. The subject of internal radiation is quietly swept under the table.

Fool me once, shame on you. Fool me twice, shame on me.

The debris from uranium munitions settles rapidly to the ground in the immediate environs of a destroyed target.

The intention behind this statement is to suggest that uranium is not dispersed far into the environment where it can become a significant inhalation hazard to our own soldiers and civilian bystanders. It is a replay of the ill-conceived notion held by Manhattan Project scientists that the radioactivity released by the atomic bomb would be confined to the area surrounding ground zero. These scientists overlooked in their calculations the lofting of radionuclides into the atmosphere, their long-range transport via the winds, and their return to earth as fallout. That the US military continues to rely on this ruse of limited dispersal was evidenced on May 6, 2003, when spokesmen for the Army's V Corps released information to the media on the safety of depleted uranium weapons being used during the second Iraq war (Gray). Included was a statement that uranium particles, being 1.7 times heavier than lead, do not stay suspended in the air for very long and settle in the immediate vicinity of the target they destroyed. This sounds seductively reasonable. Uranium is heavier than lead. It must fall out of the air rapidly. The only trouble is that it doesn't.

Depleted uranium is pyrophoric. Upon impact with an armored target, it begins to burn. The high heat ignites gasoline fumes emitted from the targeted vehicle. This is turn ignites the fuel tank, engulfing vehicle and crew in an intense blaze. According to the Army Environmental Policy Institute, up to 70% of a DU-penetrator can become aerosolized upon impact with a tank (AEPI). This material can then be lofted skyward in the rising plume of fire and smoke and travel downwind. The question is: how far?

In his article "Contamination of Persian Gulf War Veterans and Others by Depleted Uranium," Leonard Dietz makes mention of an incident that occurred in 1979 while he was employed at the Knolls Atomic Power Laboratory in Schenectady, New York. While troubleshooting a radiation problem at the facility, Dietz and his colleagues made the surprising discovery that aerosols of depleted uranium had been captured in air filters set out for environmental monitoring. The traced the origin to the contaminant to the factory of National Lead Industries, *10 miles* to the east, in the city of Colonie. At this facility, 30 mm cannon rounds were being manufactured for the Army along with DU-counterweights for airplanes. The team analyzed 16 filters from three different locations that had been exposed to the air for 25 weeks between the months of May and October. All contained trace quantities of depleted uranium. Three of these filters were located 26 miles northwest of the National Lead facility.

Dietz postulates an interesting mechanism by which particles of DU may travel even greater distances than those observed in New York state. Through frictional forces in the

air or by way of the emission of alpha radiation, a particle of depleted uranium can become electrostatically charged and become attached to oppositely charged dust particles. The average density of the two particles joined together will be less than the 11 grams per cubic centimeter of pure DU metal. By hitching a ride on sand and dust, small particles of DU can gain an advantage for achieving long-range dispersal.

Regardless of the exact distance of initial transport, once released into the environment, particles of depleted uranium are vulnerable to resuspension. Once deposited on the ground, these can be lofted skyward again by wind or such disturbances as passing vehicles and troop movements. In the shifting sandstorms of the desert, the inhalation hazard of DU can end up being widespread and perpetual. In a radio interview on Democracy Now! Dietz reiterated his contention of the long-range transport of DU particles.

> The transport of these tiny particles, which indeed do have the density of lead are unlimited. It depends on the atmospheric conditions of how the wind is blowing and what the specific conditions are. For example, a one micrometer diameter uranium dioxide particle with the density of lead falls at the rate in still air of four feet per hour. A one-half micrometer diameter particle falls at the rate of one foot per hour. Both of these size particles are literally floating in air. So when the military says that the fallout remains within a range of 50 meters or so from a tank that's been hit by a depleted uranium penetrator, they're just — it's just not true at all. They have unlimited range. They can go hundreds and hundreds of miles (Broadcast Exclusive).

The fate of National Lead Industries due to its outpouring of depleted uranium pollution is instructive of the environmental implications of waging war with weaponry fabricated from this metal. In 1980, the environmental code of the State of New York prohibited airborne emissions of radioactivity from a single facility from exceeding 150 microcuries in any given month. This amount of radioactivity is equivalent to 387 grams (or 13.8 ounces) of depleted uranium. National Lead Industries was unable to operate within these guidelines while under contract to produce DU-penetrators. As a result, in February 1980, a New York State court ordered the company to cease production and the plant was closed.[2]

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[2] In the newspaper article "'Safe' Uranium that Left a Town Contaminated" written by David Rose and published in the *Guardian Unlimited*, November 2007, further facts concerning uranium pollution in Colonie came to light. A three year study by Britain's Ministry of Defence revealed that during its decades of operation, National Lead Industries vented 10 tons of uranium oxide dust through an unfiltered chimney into the surrounding countryside. Urine samples acquired from five former

A single GAU-8/A DU penetrator fired from the under-wing cannon of an A-10 Warthog aircraft weighs 272 grams, nearly the same amount that violated the law of the State of New York. A total of 940,000 of these rounds were fired into the environment of Iraq during the First Gulf War of 1991. And this amount of DU was from just one weapon system. The M1A1 Abrams tank fires 120 mm rounds, each containing 10.7 pounds of depleted uranium, and the M1 and M60 tanks fire 105 mm rounds, each containing 8.5 pounds of DU. 14,000 of these tank rounds were fired at Iraqi tanks during the conflict. In total, over 350 metric tons of depleted uranium were released to migrate through the environment. Early unofficial estimates of the tonnage of uranium weapons deployed during the 2003 invasion of Iraq ranges from 1,000 to 1,700 metric tons. A truly accurate total is unobtainable. The United States shrouds such data behind the veil of classified information.

Human beings take uranium into their bodies all the time without any negative consequences to their health.

This is a true statement. But by once again playing on the confusion between *natural uranium* and the *uranium found in nature*, the public is asked to believe that increasing the concentrations of uranium in air, water and soil near human habitations is a benign activity. The unstated message: Human beings uptake uranium from the environment all the time. How could the uranium from weapons be hazardous to health?

To expose the fallacy in this reasoning, some basic information on the metabolism of uranium needs to be mentioned. Most of the uranium entering people's bodies on a daily basis accompanies the ingestion of food and water. Daily dietary intake amounts to approximately two millionths of a gram. *Only two billionths of a gram enters the body daily through inhalation*. The uranium contained in this daily intake is bound in a number of different chemical compounds. Some of these are soluble and some are insoluble. Of the uranium taken into the body, 98% passes right through the digestive system and is eliminated in the feces. Of the 2% that is absorbed into the bloodstream, practically all of it consists of par-

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employees and analyzed by Professor Randall Parrish of Leicester University all tested positive for DU. This was 23 years after National Lead Industires closed its doors. Twenty percent of residents tested who had spent at least 10 years living near the factory also were found to be contaminated. Between 1984 and 2007, the Army Corps of Engineers conducted a massive decommissioning project. Costing $190 million dollars, all buildings on the grounds of the facility were demolished and 150,000 tons of soil and other contaminated debris, dug from a depth of up to 40 feet, were shipped 2,000 miles by rail to radioactive wastes sites in the Rockies.

ticles of *soluble* compounds. Due to its solubility, it freely migrates throughout the body, a portion becoming lodged in the kidneys, skeleton, and other organs. Most of it is eliminated through the urine. Due to its solubility and consequent mobility, the radioactive decay from dietary uranium does not expose any cluster of cells within the body to repeated hits by alpha particles or the ions and free radicals they create. Soluble compounds of uranium primarily exert a toxic effect on the kidneys as a chemical rather than as a radiological toxic agent.

Uranium from uranium/depleted uranium weapons creates a qualitatively different kind of health hazard. As mentioned earlier, uranium is pyrophoric. The high heat generated by impact and friction with an armored target sets it burning. Temperatures within the inferno can exceed 3,000 degrees Centigrade — higher than the melting point of uranium. Due to the combination of high temperature and impact pressure, the uranium undergoes a metamorphosis. It is aerosolized and transformed into an insoluble ceramic. Anywhere from 0.9% to 70% of the uranium contained in the penetrating munition becomes aerosolized and ends up being lofted into the air on convection currents. The amount varies with the size of the penetrator, its velocity at impact, and the composition of the target. The aerosolized uranium debris consists of particles of variable size and is a mixture of soluble and insoluble compounds. The primary route of entry of this material into the human body is through inhalation.

The ICRP (International Commission on Radiological Protection) has standardized a model for studying inhalation hazards. According to this model, 25% of inhaled particles are deposited in the bronchial tree, 25% are immediately exhaled, and 50% are translocated to the nasopharynx and swallowed. What happens to the particles retained in the lung is determined by their size and solubility. Only particles ranging in size from 0.2 to 5 microns are respirable, i.e., capable of reaching the non-ciliated portion of the bronchial tree where they can become lodged and serve as a point source of radiological hazard to the surrounding pulmonary cells. According to one test conducted by the Army, the impact of a 105 mm DU penetrator weighing approximately 4 kg released 2.5 kg of airborne DU particles (Chambers *et.al.*). Sampling determined that half the liberated particles were in the respirable range. When inhaled, the soluble portion of these particles are available for absorption into the systemic circulation either in the upper bronchial tree or on the surface of the alveoli where oxygen-carbon dioxide exchange takes place. The smaller the particles, the more likely it is that they will reach the alveolar surfaces. Once absorbed into the blood, they will behave similarly to soluble particles entering the systemic circulation through the intestines. As mentioned earlier, the hazard posed by soluble uranium is primarily to the kidneys as a chemically toxic agent rather than as a radiologically toxic agent.

The insoluble particles trapped deep in the lung and near the alveolar surfaces present an entirely different physiological picture. These particles are relatively immobile. As a consequence, during the course of their residency, the damage caused by the alpha radiation emitted by the decaying atoms within the particle is confined to a very small spherical volume with a radius of 30 microns, or five cell diameters, which is the maximum distance capable of being traversed by alpha radiation. As time passes, more radiation is emitted within this small volume, creating a major radiological hazard to the targeted cells. The residency time of insoluble particles in the lung is relatively long. It is estimated that these particles have a biological half-life of 120 days. One study, however, reported that 60% of insoluble uranium retained in the lung was present after 500 days (Ensminger *et.al.*). With the passage of time, these particles are slowly scavenged by macrophages from the lungs and transported to the tracheobronchial lymph nodes. These tiny tissues, weighing only 16.5 grams, can become the repository of a high concentration of insoluble particles (Busby, Hazards). Prolonged residency within this tissue can pose a radiological hazard to stem cells. This in turn has the potential of creating compromised immune function or leukemia. Furthermore, insoluble uranium particles have the possibility of escaping from the lymph nodes and circulating everywhere in the body (Busby 2001). In contrast to soluble particles, insoluble particles do proportionately more damage via their radiological properties than their chemical properties. Insoluble uranium has an affinity for uptake by bone. Deposit in this tissue will result in long-term biological retention. A portion may remain trapped for the entire lifespan of the organism. Whether deposited in bones or other organs, insoluble particles are slow to be eliminated from the body. If they are in range of radiosensitive components within their target organ, there is a significant probability that they can induce malignant alterations.

It is misleading to compare exposure and dosages of uranium taken into the human body via the diet with the uranium/depleted uranium of weapons that deliver to the human body an inhalation hazard of insoluble particles that are more concentrated, more radioactive, and retained for substantially longer periods of time at their point of deposition. The two present different types of hazards to different organs of the human body. Regardless of its route of delivery, and regardless of what government propaganda machines pronounce, uranium represents a radiological hazard to the human body. Referring to the stochastic (probabilistic) theory of radiation effects, Durakovic makes the following statement in the article "Medical Effects of Internal Contamination with Uranium:" "Although the individual exposures are frequently low, the corpuscular radiation, organ-specificity, and long physical and biological half-life render uranium a radiological hazard with no-threshold effects in the internal environment of the contaminated organism" (Durakovic 1999).

The rapid excretion of uranium from the body prevents it from being a radiological hazard to health.

To ensure that the world slumbers on while radiological warfare is waged, the reigning power structure must convince the public of one of two alternatives: (1) Debris from uranium/depleted uranium munitions released in the environment is not internalized by combatants and civilians. (2) In situations where it can no longer be denied that uranium/depleted uranium is being internalized, the fallback position is to convince people that it is metabolized in such a way as to be rapidly eliminated before sufficient radioactive decay releases hazardous doses of radiation within the body's interior. For this strategy to succeed, scientific investigation on all aspects of uranium weaponry and its biological effects must be controlled. The first tactic is to avoid doing research altogether. The second is purposely to avoid identifying those who received internal contamination. The third is to misrepresent the existing knowledge base. The fourth is to conduct meaningless research and sell the world on the veracity of its conclusions. This, in a nutshell, is what has transpired to date.

Since the introduction of uranium munitions during Operation Desert Storm, controversy has brewed around the globe over their purported safety. In response, the United States has brazenly continued to deploy more such weaponry with each subsequent conflict. By failing to take leadership in sponsoring honest scientific investigation into a possible link between depleted uranium contamination and Gulf War Illness, the US has failed to reassure the world of the safety of its new weapons.

The Department of Defense and the Department of Veterans Affairs have to date been playing a wicked game with their ailing veterans by intentionally misleading them into the belief that they did not suffer exposure to depleted uranium on the battlefield. In the immediate aftermath of the Gulf War, the government took the stance that no evidence existed that any soldiers, other than 33 who were injured in friendly-fire incidents, received dosages of depleted uranium on the battlefield. The reason no evidence existed of more widespread contamination was that no veterans were properly examined.

As anecdotal evidence began accumulating of the link between battlefield exposure to DU and subsequent illness, the government moved more ingeniously to deflect criticism of its new weaponry. They provided free medical assessment to any veteran who requested it, but they conducted spurious urine tests which, unbeknownst to ailing vets, were guaranteed to indicate no exposure to uranium. This testing misled those who were ill into

believing that no lingering hazard of depleted uranium remained within their tissues.

When one receives an acute dose of uranium/depleted uranium, a standardized measurement of total uranium in a 24-hour urine test, *conducted soon after exposure,* will reveal elevated concentrations of soluble compounds of uranium in the urine. With the passage of time, however, total uranium in the urine will diminish as the body progressively eliminates the substance until uranium levels return to within normal ranges. On the other hand, the portion of insoluble compounds of uranium/depleted uranium that becomes trapped in lungs, bone and other tissues of retention will slowly be released over years into the circulation and become inseparably mixed with the uranium naturally circulating through the body from normal pathways of intake. Measurements of total uranium taken at this point provide no information about any contamination from depleted uranium that may have occurred years earlier since the DU present in urine will be intermixed with the uranium naturally present in the body.

Unsuspecting victims of uranium contamination are preyed upon by government trickery over this technicality of what actually is being measured with a 24-hour urine sample. In the distorted world view of government science, uranium, which is a radioactive element, is incapable of posing a radiological hazard. The hazard to health from internalized uranium is considered solely in terms of its chemical properties. The degree of chemical toxicity is directly related to the *systemic body burden level*, or total uranium, measured in a 24-hour urine sample. If the urine sample provides no evidence of levels of uranium elevated above the normal range, the GI is pronounced uncontaminated. What government physicians fail to communicate to their unwitting patients is that within weeks of exposure, the body excretes excess quantities of soluble uranium and urine levels quickly return to within normal range. Thus, 24-hour urine tests performed years after exposure are guaranteed *not* to provide evidence of contamination. The piece of information hidden from veterans is the fate of that portion of internalized uranium that is bound up within insoluble compounds. Under battlefield conditions, soldiers can inhale medically significant quantities of insoluble uranium that will be deposited and retained in the lungs for long periods of time, perhaps as long as decades. The slow leaching of this uranium into the systemic circulation will go undetected in 24-hour urine samples, for it will not raise total uranium levels in urine above normal ranges. Thus, this type of test is totally fraudulent where it concludes that no contamination has occurred in the past or that elevated quantities of uranium/depleted uranium are not lodged in tissue.

The government covered up the extent of DU contamination in veterans by postponing testing for as long possible. In 1994, three years after the Gulf War, the Department of Defense established the Comprehensive Clinical Evaluation Program on behalf of veterans

who believed that they had received service-related injury to their health. As of January 2001, 57,048 veterans had registered in the program. Of these, 16,180 declined a medical exam. Of the remaining, 40,686 were put through a battery of tests which included measurement of total uranium in their urine. Surprise! Surprise! Veterans were found not to have elevated levels of uranium in their urine. By this finding, veterans were misled into believing that they had not been contaminated. What they were not told was that the measurement of total uranium in urine is a useless indicator of contamination acquired years earlier and that it is incapable of detecting insoluble uranium deposited in their tissues.

For a decade, the Pentagon successfully managed the public uproar over the use of depleted uranium in munitions by proudly proclaiming that there was no proof that any veterans were contaminated. While this public relations campaign was victorious, sick veterans were at a loss to discover what was responsible for their declining health and miserable lives, and they continued to live with the nagging uncertainty about whether uranium contamination had anything to do with their illnesses.

Truth always has the power to triumph over falsehood. And it was the advancement of scientific truth that turned the tide of tomfoolery about denials of contamination in veterans. In August 2000, at the annual meeting of the European Association of Nuclear Medicine in Paris, Dr. Asaf Durakovic reported on a study conducted on Gulf War veterans which followed a new protocol for the detection of depleted uranium in urine samples. This information was later published in the journal *Military Medicine* (Durakovic *et al*., 2002). This research definitively established that the presence of depleted uranium in urine can be determined at least nine years after exposure. These findings were politically explosive. For the first time, those contaminated with depleted uranium could be unmistakably identified. Since publication, labs all over the world have adopted the new protocol and are using it to identify victims of depleted uranium contamination.

The study undertaken by Durakovic, Horan and Dietz sought to determine the relative concentration and ratio of the different uranium isotopes in the urine of ailing veterans. When one realizes that the difference between uranium-238 and uranium-235 is the weight of a mere three neutrons, one can begin to appreciate the sophistication of equipment and methodology required to attain accurate results. Chosen for study was a population of 27 veterans who had a history of DU inhalation exposure eight to nine years before the study. All presented complex, nonspecific symptoms of Gulf War Illness. Twenty-four hour urine samples were gathered from all test subjects. The urine was evaporated to near dryness and the residue was chemically treated to dissolve all insoluble ceramic DU particles. The uranium content was then separated from all other substances, purified by ion exchange chemistry, and concentrated. The isotopic composition was then

measured by a thermal ionization mass spectrometer. This technique represents the most sophisticated, state-of-the-art method currently available for analyzing uranium isotopes in a sample.

The logic for the study was based on the fact that the isotopes of the uranium found in nature exist in a different ratio to each other than those found in depleted uranium. Both types of uranium consist of U-238, U-235 and U-234.[3] By measuring the relative concentration of these isotopes in a sample and calculating their ratios, the type of uranium can be identified. Even when the two types of uranium are mixed together, which occurs when someone's body containing the uranium found in nature is contaminated by DU, the ratios can be used to determine exposure. "The different ratios of the isotopes are unique fingerprints that allow the DU fraction to be calculated accurately, even though it always is mixed with natural uranium" (Dietz 1999). The uranium found in nature, which normally passes in and out of the human body, consists of U-238 at a concentration of 99.2739% and U-235 at a concentration of 0.7200%. The ratio between the two (238/235) is 137.88. The relative concentrations of the two isotopes is different in depleted uranium due to the fact that a portion of U-235 has been removed and the relative concentration of U-238 has been increased. In a piece of DU shrapnel analyzed in the study, U-238 existed in a higher concentration of 99.7945% and U-235 in a lower concentration of 0.2026%. The ratio between the two was 492.60. If depleted uranium is present in the body and intermixed with the naturally occurring uranium, the ratio of U-238 to U-235 increases above 137.88. This is because the DU adds relatively more U-238 to the body's natural level while diluting the natural level of U-235.

In the study, the ratio of U-238 to U-235 in 11 test subjects was found to be between 137.43 and 140.25. These results indicated that the uranium in the urine of these veterans, allowing for acceptable margins of error in measurement, was the uranium found in nature. In other words, they showed no evidence of contamination. However, 14 other veterans tested positive for the presence of depleted uranium with the ratio of U-238 to U-235 ranging from a low of 143.47 to a high of 426.46. The average within this group was 207.15. Autopsy specimens from one deceased veteran returned a ratio of 143.20 in the lung, 140.20 in the liver and 147.80 in the bone, indicating DU contamination in these tissues.

To all veterans of future wars: this is ***the*** test that must be performed to determine the presence of depleted uranium within your bodies.

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[3] Depleted uranium also contains U-236. This isotope is not found in nature. It is found in spent nuclear fuel, produced in a nuclear reactor when atoms of U-235 capture a neutron. Thus, the presence of U-236 in DU is a tell-tale signature that the uranium is contaminated with reprocessed uranium.

Durakovic and colleagues carried their initial research further. They formulated a method of estimating retrospectively the initial quantity of depleted uranium taken into the body at time zero and followed this up with research on estimating cumulative radiation dosage (Durakovic *et al.*, 2003a,c). These studies reveal that some veterans inhaled sufficient uranium and retained it long enough to provide lung dosages above regulatory limits. This is an extraordinary finding. The quantities of inhaled uranium by soldiers on the battlefield was purported to be insignificant and incapable of presenting a radiological hazard. This new information is an indication that mass testing of potentially exposed GIs and enemy noncombatants is warranted and should be undertaken.

One point needs to be driven home. If depleted uranium is being detected in urine eight or nine years after exposure, this indicates that throughout this whole period of time the internal environment of the body has been receiving ongoing chemical and radiation exposure at the sites of retention. Cells within range of alpha-emitting particles lodged in tissues were vulnerable to repeated damage due to recurring alterations of their molecular/chemical environment. Under these circumstances, the radioactivity of uranium cannot be discounted as a hazard to health.

A review of the scientific literature provides no evidence that internalized uranium in the quantities released by uranium weapons presents a significant radiological hazard.

The health effects of uranium have been studied more extensively than that of any other element. A vast amount of research has been conducted on uranium's physical, chemical, radiological and toxicological properties. Despite this body of knowledge, experts in internal contamination admit to uncertainty as to the full range of biological effects of low doses of uranium. It is disingenuous to make definitive statements on the safety of uranium munitions when large gaps exist in the knowledge base.

It is essential to realize that the use of uranium weaponry is the first instance in history of the mass contamination of populations with a single radionuclide. In actuality, there are few studies that contain information relevant to understanding uranium toxicity as it applies to the inhalation of insoluble particles of natural and depleted uranium. As Rosalie Bertell has written:

> The more soluble compounds of uranium, namely, uranium hexafluoride, uranyl fluoride, uranium tetrachloride, uranyl nitrate hexahy-

> drate, are likely to be absorbed into the blood from the alveolar pockets in the lungs within days of exposure. Although inhalation products also are transported through coughing and mucociliary action to the gastrointestinal tract, only about 2% of this fraction is actually absorbed into the body fluids through the intestinal wall.
>
> Therefore all of the research papers on acute effects of uranium refer to these soluble uranium compounds via inhalation. The main acute effect of inhalation of soluble uranium compounds is damage to the renal system, and the main long-term storage place of these compounds in the body is bone. These research findings do not apply easily to the insoluble uranium compounds to which the Gulf Veterans were exposed when the depleted uranium ordnance was used in battle (Bertell 1999).

Further, as Durakovic observes:

> Although the bronchoalveolar pathway is the single most important point of entry of uranium in the internal environment of the human organism, there have been very few controlled exposures of man to uranium compounds by inhalation. The size of the dust particles in uranium mining or other dust concentration in the uranium industry were considered too large to reach the micro-bronchiolar and alveolar compartment of the human lung. It was assumed that these particles would be deposited in the nasopharyngeal region, where they could be swallowed and eliminated by the gastrointestinal tract. In uranium plants, sampling of the particle size indicated a probability of up to 99% of the dust being concentrated in the upper respiratory tract (Durakovic 1999).

As previously mentioned, burning uranium creates aerosolized insoluble particles that are generally smaller than those encountered in the atmosphere of uranium mines and uranium mills. It is these particles that are capable of reaching the non-ciliated portion of the bronchial tree and being retained internally for long periods of time. Consequently, studies of uranium workers are not relevant to the situation of soldiers exposed to uranium/depleted uranium on the battlefield or that of innocent civilians downwind.

There are a host of variables that need to be taken into account in order to evaluate the effects of internalized uranium. The complexity of the phenomenon makes it immune to simplifications, such as in the simplistic government assurances that uranium munitions cause no radiological consequences. One of the best overviews of the many fac-

tors in play is found in an article entitled "On Depleted Uranium: Gulf War and Balkan Syndrome" by Dr. Asaf Durakovic. In it, he writes:

> The scientific inquiry into DU as a possible etiological factor in the causology of Gulf War and Balkan conflict illnesses has not been met with unbiased scientific criticism. Some of the arguments relate to the short range of alpha particles, the others to the radiation being too low to induce mutagenic and oncogenic effects. Most of the polemics are in the arenas of extremely polarized interest groups on both sides of the fence, each side conspicuously lacking presence of the actual experts on actinides. The opinions are commonly exchanged in the mass media by the non-experts, and often by non-professionals, inevitably ignoring the complexity of DU interactions with the internal environment of stem and dividing transit cell population, basic laws of radiation biology and cellular radiosensitivity to alpha interactions, and effects of organotropic radionuclides in the human body, unskillfully navigating through uncharted seas of low level radiation. As usual, truth is often found between the extremes of the Confucian pendulum, easier found in the science textbooks than on the Internet screen, which often lacks the basics of chemical synchronization, mitotic selection, fundamentals of the mitotic cell collection, and uniformity of cell cycle, cell culture, survival curves, and cellular response to radiation. The biological effects of DU do not differ from other alpha and beta internally deposited emitters and have to be considered in the light of cellular radiosensitivity as related to the mitotic cycle, with clear concepts of radiosensitivity and radioresistance in different phases of the mitotic cycle. The intermitotic and dividing cell population in the vicinity of final retention sites of depleted uranium includes pluripotent stem cells, hematopoietic system, intestinal villi crypt cells, intermitotic pool in the bone marrow, and basal cells of the skin. The mechanisms of DU interactions are far from being adequately understood even by the experts. Thus, it is perhaps premature to classify DU as a nonhazardous substance, even if the proponents manage to master the basics of the host of factors that determine the biological consequences of internal particulate emitters, including dose-rate effects, linear energy transfer, oxygen effects, relative biological effectiveness, repair mechanisms, and damage recovery (Durakovic 2001).

To offer a brief commentary on Dr. Durakovic's observations, the radiological effects of uranium internalized with the human body are dependent on a number of variables which may even vary from one exposed person to another. How the radiation of

decaying uranium atoms is delivered in space and time to the cellular environment in its immediate vicinity is critical to determining its effects. The final outcome of the radiation deposited is significantly dependent on the type of cell(s) the decaying atoms are in proximity to, the rate of replication of these cells, their radiosensitivity, and the phase in the cell cycle which the target cell(s) are in when disturbed by the emitted radiation. Not to be ignored are the biochemical disturbances created by massive ionization and free radical formation. Further, the sites in the body where uranium is retained bring it into proximity with some of the most radiosensitive cells of the body, including the pluripotent stem cells, cells of the hematopoietic system, intestinal villi crypt cells, and bone marrow cells. The complexities involved in the interaction between low levels of radiation, the cell cycle of different populations of cells, and the resulting alteration of cellular biochemistry precludes blanket statements that claim internalized uranium is radiologically nonhazardous. Further, no research is available on the cumulative effects to the organism as a whole from the multiple disturbances to different cell populations resulting from the deposition of thousands or millions of uranium particles throughout the body.

In a radio interview, Dr. Durakovic was asked about the prognosis of people contaminated by depleted uranium. His reply is instructive:

> The prognosis is still being debated in the scientific literature. I can tell you what the government of the United States studies indicate. At the Armed Forces Radiobiology Research Institute in Bethesda, Maryland, studies were done that confirmed carcinogenesis from depleted uranium, which means depleted uranium isotopes in the cell culture show transformation of the immature cells of the human tissues into cancer cells. Which means carcinogenesis or capacity to cause cancer is definitely proven in the scientific experiments. Genetic changes are definitely proven by the studies that were done on my patients from the Gulf War I, at the University of Bremen in Germany, where scientists confirmed significant changes in the chromosomal structure in the patients who were referred to them for their chromosomal analysis. The immune system can be affected. The reproductive system can be affected. The central nervous system can be affected, and many tissues — kidneys, obviously, because of the chemical toxicity in uranium. We are talking about multi-organ risk to the people who are contaminated with uranium isotopes. And how realistic is that risk? We don't know because epidemiological studies have been either insufficient or not even started, even at institutions like the World Health Organization. We don't know the practical implications of the levels of contamination we are dealing with now, but we do know that science has no contradiction about the harmful

> effects of uranium isotopes in the human body. The prognosis that you were asking about cannot really be determined without many studies to be conducted in the future (Broadcast Exclusive).

The bottom line is that science has yet to unravel the full physiological impact of internalized uranium. Despite this state of relative ignorance, the government of the United States is using uranium as a weapon of war and scattering it amidst human populations. Assurances to the public that there is no scientific reason to believe such deeds are hazardous is a ruse employed to deflect attention from the fact that no research has been done to determine the health impact of uranium weapons on targeted populations. What is required is further research. Disturbingly, this research is not being undertaken by government. Currently, there are no major research projects underway that adequately address the health effects of uranium weapons. Meaningful data is emerging only from the studies conducted by small, inadequately funded private organizations. The lack of relevant research is itself an indictment against the powers that be and an indication that truth and human well-being are not the highest priority when overwhelming military might is at issue.

An individual exposed to depleted uranium receives less radiation than one normally receives from natural background radiation.

This is a sophisticated argument of profound cleverness. The apparent logic of it is so seductive and confounding that it is dragged out and dusted off in every discussion of radiation exposure to the public. The scattering of radioactive material in the biosphere, be it from fallout from nuclear weapons, routine or catastrophic releases from nuclear power plants and weapon production facilities, the seepage of radioactive waste into the environment from storage sites, or uranium munitions, is *always* deemed safe on the grounds that it creates less radiation exposure to the public than natural background radiation. The deeds of the Cult of Nuclearists are built upon this argument. By it, they hope to convince all that the scattering of human-generated radioactivity into the environment is an innocuous enterprise with inconsequential risks to public health. The logic of their argument runs something like this: Ionizing radiation occurs naturally on the face of the Earth. Life evolved within this radiation field. The fact that we're all here is indicative that biological systems have evolved mechanisms for repairing molecular and cellular damage induced by the amount of radiation routinely encountered in the environment. This innate capacity for biological repair will surely not be overwhelmed by the additional radiation introduced

into the environment by human activities.

To be alive on planet Earth is to be bathed in low levels of ionizing radiation. No organism can escape this phenomenon. Every living creature receives external exposure from the surrounding environment and internal exposure from the inhalation, ingestion, and absorption of radioactive atoms present in the air, food and water. The sources of this radioactivity are diverse. Our planet is constantly being bombarded by *cosmic radiation*, highly energetic, subatomic particles from space. These are most often single protons but may also be heavier atomic nuclei. Most of this radiation is attenuated by interaction with molecules in the upper atmosphere which in turn creates a shower of secondary photons and particles. Most of this secondary radiation is stopped before reaching the planet's surface. Some, however, does manage to reach the ground and penetrate the bodies of Earth's creatures. Cosmic radiation can also induce stable atoms drifting in the atmosphere or on the ground to become radioactive. The majority of this *cosmogenic radioactivity* quickly decays but a small portion does persist. Included among these radionuclides are tritium, carbon-14 and beryllium-7. Present in low concentrations within the human body, these contribute little to annual dosages. *Terrestrial radiation* is of primordial origin, present originally on the face of the Earth in the form of such long-lived radionuclides as uranium-238, uranium-235 and thorium-232. Over the eons, as these series radionuclides have undergone radioactive decay, they have given rise to families of radionuclides that have decayed in sequence into other radionuclides. By this means, a variety of radionuclides has appeared on earth in trace quantities. These radionuclides are present in all soils and rocks. Organisms can receive external radiation when these undergo radioactive decay in the environment. These radionuclides can also gain entrance into the body. Once deposited within, they can be a source of internal radiation.

One radionuclide that has received a great deal of media attention in recent years is radon-222, which is part of the decay series of uranium-238. Radon is the decay product of radium-226. It exists as a gas, emits alpha radiation, and gives rise to short-lived "daughter" isotopes. These radon daughters are also alpha emitters. Although not themselves gases, they frequently become attached to dust particles and are drawn into the lungs where they transmit radiation to radiosensitive tissues. Besides radon, other naturally occurring radioisotopes contribute to internal exposure. The most significant of these is potassium-40 which is very diffusely distributed throughout the body.

Altogether, the average person in the United States receives an annual dose of approximately 300 millirems from natural sources of radioactivity in the environment. On average, every person receives an additional dose of 60 millirems by way of medical x-rays, nuclear medicine procedures, consumer products, and the remnants of global fallout from

past nuclear weapon tests. Often included in this category are other forms of pollution released by the nuclear industry. These inclusions are often presented in deceptive ways. For instance, the amount of radiation escaping into the environment from nuclear installations is sometimes *averaged* over the entire population as if exposure were equally distributed to everyone. By this means, the released radiation is made to appear as an insignificant contribution to background radiation. However, frequently, it is not the whole population that is exposed but rather those living immediately downwind from nuclear installations. This is yet another mathematical stunt that can be relied upon to cover-up radiation injury to a population.

To summarize, the annual whole-body dose to the US population from different sources of background radiation is provided in the following table.

Annual estimated average effective dose equivalent received by a member of the population of the United States (Idaho State University)

Source	**Average Annual Effective Dose Equivalent**	
	microSievert	millirem
Inhaled (Radon and Decay Products	2000	200
Other Internally Deposited Radionuclides	390	39
Terrestrial Radiation	280	28
Cosmic Radiation	270	27
Cosmogenic Radioactivity	10	1
Rounded Total From Natural Source	3000	300
Rounded Total From Artificial Sources	600	60
Total	3600	360

It is interesting to note in passing that the European Committee on Radiation Risk (ECRR) takes exception to the inclusion of radon inhalation in such calculations of annual whole-body exposure from background radiation:

> While most of the nuclear-related doses to people are given in terms of whole-body dose, radon dose is actually to bronchial epithelium and not to the whole body, although this is not acknowledged. Radon gas exposure to bronchial epithelium cannot just be added in to increase so-called natural background whole-body radiation.
>
> Much of the radon gas problem of today has been generated by uranium activities in support of nuclear weapons and nuclear power since 1950: this includes radon released from uranium wastes discharged to the sea. To summarize, the committee believes that the doses from radon and its daughters have been overstated and that this misrepresentation has had the effect of minimizing the contributions to human exposure from artificial radionuclides (ECRR).

The issue highlighted by the ECRR is that it is inappropriate to include radon inhalation as part of "natural" whole-body background radiation. The radon hazard of today is in large part a result of human activity initiated within the last 60 years. Further, radon does not provide a whole-body dose but a localized dose to bronchial epithelium. Thus, the inclusion of radon is a political tactic designed to suggest that human beings receive greater whole-body doses from natural background radiation than they actually do. This has the effect of making the annual dose from human-generated nuclear pollution appear comparatively less than it actually is.

Apologists for the deployment of uranium/depleted uranium weapons make a powerful argument when they claim that the radiation dose received by exposure to these weapons is less than that received by natural background radiation. However, they are inappropriately comparing two different types of radiation that deliver their hazard by different means.

The European Committee on Radiation Risk cautions that many inaccuracies may creep into arguments when different types of radiation exposure are compared: "The committee is anxious to establish the principle that each exposure should be assessed at the cellular level and that therefore comparisons across types of exposure are unsafe" (ECRR). According to the ECRR, three types of errors typically crop up in arguments that compare different types of radiation exposure:

1) Exposure to radioisotopes found in nature is incorrectly compared to exposure to novel radioisotopes fabricated by human activity. Such a comparison can obfuscate the different contribution made by the two to internal exposure. The confusion sown by this type

of invalid comparison was uncovered earlier in the section discussing the differences between natural uranium and the uranium found in nature.

2) External radiation is incorrectly compared to internal radiation. This is another invalid comparison due to the fact that exposure of cells to the two is both qualitatively and quantitatively different. This is the fallacy upon which much of current radiation safety is based.

3) Sometimes, natural forms of isotopes are inappropriately compared to technically enhanced natural isotopes. This is often not valid because the two may differ in their physicochemical forms. An example of this was mentioned earlier in this chapter in the discussion of the effort to liken soluble uranium found in nature that is absorbed in the gut and diffusely distributed in the body to concentrated, insoluble uranium particles inhaled into the lungs from uranium weapons.

It is now apparent how fallacious it is to compare exposure to background radiation with radiation exposure received from uranium/depleted uranium weapons. Annual background radiation exposure refers to whole-body exposure to the ionizing radiation naturally present in the environment plus that normally received by the population from medical procedures. Much of this exposure is from external radiation, and with the exception of radon, which delivers its entire dose to lung epithelium, the remaining internal emitters such as carbon-14 and potassium-40 are diffusely distributed throughout the whole body and likewise deliver their radiation diffusely. In contrast, uranium/depleted uranium from weapons creates a wholly internal hazard, where concentrated quantities of energy are deposited via alpha radiation to the small cluster of cells surrounding each embedded particle.

If natural background radiation is to be meaningfully compared with radiation from uranium weapons, a common frame of reference needs to be chosen which takes into account the effects each type of radiation has on the body. According to the ECRR, this frame of reference should be the effects produced at the cellular level by each type of radiation. When this comparison is made, it cannot be disputed that uranium weapons create a radiological hazard that is vastly greater than that posed to the human organism by natural background radiation.

Many researchers in cellular radiobiology have identified the most critical radiation-induced lesion to a cell as a double-strand break of the DNA molecule (Simmons and Watt). The likelihood of this type of damage being accurately repaired by natural repair mechanisms is considered much less probable than the repair of a single-strand break of the dou-

ble-helix molecule. Consequently, double-strand breaks are far more likely to initiate cell death, or more critically, mutation, which can result in altered function and/or the genesis of uncontrolled replication and tumor formation. Double-strand breaks can be produced along a single track of ionization by, in order of decreasing likelihood, a heavy charged particle, a beta particle, or a secondary electron produced by photon interactions. For this outcome to occur, two ionizing events must take place along the track at a separation of approximately two nanometers, the distance between the two strands of the DNA molecule. Alternatively, double-strand breaks can be produced when two or more separate tracks intersect the same DNA molecule within a time frame of between five to 14 hours, the time period required for the first single-strand break to be repaired. Therefore, among other things, the type of radiation, the energy transmitted by that radiation, and the time period over which it is delivered all become factors in determining the number of tracks passing through the critical volume of the cell per unit time, the density of ionization along these tracks, and the probability of a double-strand break being created.

The issue now revolves around whether the radiation from uranium/depleted uranium is more or less likely than natural background radiation to induce double-strand breaks at the level of the cell. An answer is not hard to come by since the hazard to individual cells from background radiation has already been the subject of scientific scrutiny. As a result of this research, one fact stands out as particularly interesting: "*At natural background exposure levels of 2 mSv, cells on average receive 1 hit per year* [italics added]" (Goodhead). In this low-dose region, "there are so few radiation tracks that a single cell or nucleus is very unlikely to be hit by more than one track. The chances of two tracks from randomly distributed external irradiation intercepting the same cell during the 12-hour repair period is vanishingly small" (Busby 1995). What about that portion of natural background radiation resulting from internal emitters such as carbon-14 and potassium-40? When undergoing radioactive decay, these radioisotopes do not initiate a series of multiple decays but undergo only a single decay. Their diffuse presence in the body and their mode of decay mean that the possibility of initiating double-strand breaks is infinitesimally small.

By contrast, particles of insoluble uranium which are embedded in tissue present a much more hazardous scenario. Being immobilized, their ongoing target is the same tiny cluster of cells in their immediate vicinity. The tracks produced in this volume by their emitted alpha particles have a much greater probability of passing through the cell nuclei of nearby cells and of causing multiple ionizations in the critical two-nanometer distance between the individual strands of the DNA molecule. Further, alarming evidence exists that uranyl UO_2^{++} ions bind strongly to DNA (Wu *et al.*). The inhalation of debris from uranium/depleted uranium weapons has the capacity to ferry radioactivity directly to the most critically sensitive target of a living organism.

When cellular effects are the variable studied, depleted uranium is revealed to have a far greater capacity than natural background radiation to produce critical lesions in genetic material. It is fallacious to suggest that the radiation emitted by uranium/depleted uranium weapons is of no more consequence to health than the radiation we are naturally exposed to from the environment.

Unless kidney damage is apparent, levels of internalized uranium can be considered insufficient to present a radiological hazard.

The position taken by the Veterans Administration is that the primary hazard from uranium is its chemical toxicity, not its radioactivity. If a veteran does not evidence kidney damage, he has not been injured by uranium.

Uranium, like other heavy metals, is a chemically toxic agent when incorporated in sufficient quantities into the human body. Uranium is known to be toxic to the proximal convoluted tubule of the kidney where it produces both structural and functional damage. The amount of uranium that needs to be absorbed by the body in order to create alterations in the kidney is well-known. It is assumed, since research up to this point has been scanty, that battlefield exposure to uranium is in dosages smaller than that required to create kidney damage. In the case of the DU ammunition fired during Operation Desert Storm in 1991, this was, for the most part, probably true. However, the precision-guided bombs and bunker-busters deployed in Afghanistan and Iraq II offer an entirely different picture. These weapons contain massive quantities of uranium. People caught close to the sites of detonation of these explosives may indeed have taken into their bodies dosages of uranium high enough to be detrimental to kidney function.

After the war in Afghanistan, the levels of uranium measured in the urine of civilians exposed to the plumes of precision-guided weapons yielded two critical findings (Weyman 2002). First, at least some of the weapons deployed in that war were different from the depleted uranium weapons used in Iraq I, Bosnia and Kosovo. Mass spectrometer analysis of urine samples revealed the presence of high levels of "natural" uranium. Unbeknownst to the rest of the world, the United States is likely to be using other types of radiological material in its weaponry in addition to depleted uranium. Second, uranium in some of those urine samples existed in concentrations 400 to 2000 times higher than in urine samples drawn from control subjects dwelling in the same vicinity but not exposed to munitions plumes The amount of uranium internalized by these Afghan victims was hov-

ering at levels where damage to kidney function was a distinct possibility (Durakovic, Parrish *et al.*).

It is disingenuous to use evidence of kidney damage as the criterion for determining the radiological impact of internalized uranium. This is a political maneuver used to draw attention away from uranium's radiotoxicity and to control the direction of research into Gulf War Illness. A number of standardized tests are available to provide evidence of kidney malfunction. If sick veterans do not manifest signs of kidney damage, uranium is summarily dismissed as a possible etiological factor in their illnesses. By this means, the radiological impact of insoluble particles of uranium/depleted uranium trapped in lung and lymph nodes and only slowly mobilized into the general circulation is conveniently overlooked. As Dr. Rosalie Bertell has noted:

> It is important to note that there is no scientific evidence supporting the US Veteran Administration's claim that the insoluble uranium oxide to which the Gulf War Veterans were exposed will be primarily a renal chemical toxicant. Yet this is the criterion that the VA proposes for attributing any health problems of the Veterans to depleted uranium. Intermediate and chronic exposure duration to insoluble uranium is regulated in the US through its radiological property. The slow excretion rate of the uranium oxide allows for some kidney and tubule repair and regeneration. Moreover, because of the long biological half-life, much of the uranium is still being stored in the body and has not yet passed through the kidneys. The direct damage to lungs and kidneys by uranium compounds is thought to be the result of the combined radiation and chemical properties, and it is difficult to attribute a portion of the damage to these separate factors which cannot be separated in life (Bertell 1999).

The contamination caused by uranium munitions may represent an entirely new disease entity. All the major studies published on depleted uranium, including those of the World Health Organization, the Royal Society in Britain and the Rand Corporation and the National Research Council in the United States, proclaim the radiological safety of depleted uranium based on past research that has no relevance to the inhalation of aerosolized, insoluble, ceramic particles of uranium. New research specifically tailored to current realities must be undertaken to establish the truth of the matter. Such an investigative effort would not be difficult. There are more than 100,000 ailing veterans from the First Gulf War available as subjects. A new protocol now exists for determining depleted uranium exposure, even a decade after the fact, by the mass spectrometer analysis of urine samples. But such research is not being conducted. Given sufficient time, DU levels in the

urine will slip below the detectable range, and this avenue of investigation will be closed off. The only consolation, if it can be considered as such, is that new wars bring new opportunities.

The topic of what health effects are produced by ionizing radiation is tightly controlled. Government agencies and organizations such as the ICRP have deliberately confined discussion of health hazards from low and intermediate dose ranges to cancer. They also acknowledge the possibility of genetic damage and IQ retardation. This is stated explicitly by Rosalie Bertell: "the recognized biological endpoints deemed to be of concern for regulatory purposes are limited to radiation induced fatal cancers and serious genetic diseases in live born offspring (Bertell, February 1998). It must be emphasized that such a narrow focus is strictly an **administrative decision** of the ICRP, not one based on science. As if in collusion, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the Committee on the Biological Effects of Ionizing Radiation (BEIR), the National Council on Radiation Protection (NCRP), the National Radiation Protection Board (NRPB) in the United Kingdom, and all member state agencies of the European Union neglect to emphasize the other pathologies that may be induced by exposure to ionizing radiation. These include nonfatal cancers, benign neoplasms, infant mortality, birthrate reduction, low birthweights, congenital malformations and diseases which are not inheritable, and general reduction in health and nonspecific life shortening (ECRR). By ignoring these medical effects, exposure to ionizing radiation is made to appear more benign than it is in fact. Further, this narrow focus on the induction of **fatal** cancers has diverted the direction of scientific research. The full range of debilitating health effects being induced by exposure to radiation has yet to be explored, as the following excerpts make clear:

> In the early 1950's, when it was generally recognized that using the erythema dose, the dose which actually burnt the skin, was not adequate as a guide to radiation protection, many different biological endpoints were proposed as guides to regulatory standards: reproductive problems, tumors, congenital malformations, cataracts, blood disorders. Other possible biological endpoints were added later: obesity, hormonal disruptions, autoimmune diseases, developmental disorders, mental and physical retardation. ICRP decided that people should only be concerned about fatal cancers, and the only biological mechanism to be considered would be direct damage to DNA. Most of the other endpoints are dismissed as transient, not consequential, not damaging of the gene pool, or not fatal. This is an administrative, not a scientific decision, with which we may well wish to disagree. Even with respect to fatal cancers, those which were promoted or

> accelerated by the radiation exposure are not counted, because they are not considered to be "radiation induced" (Bertell, February 1998).
>
> The committee [ICRP] decided to base the standards on fatal cancers, and since then the arguments have centered around just how many fatal cancers would be caused by exposure of the Standard Man to one rem (or equivalently, 10 mSv) of whole body ionizing radiation exposure. The carefully worded statement is: "What people should be concerned about after radiation exposure is fatal cancer." The many other possible damages have faded into the background (Bertell 1995).
>
> The very narrow focus of ICRP on one biological mechanism of damage to one type of molecule, namely DNA, and neglect of all other mechanisms and molecular damage from ionizing radiation, is scientifically abhorrent and practically very prejudicial to the victims of radiation. There are now attempts to further restrict this narrow focus to health effects due to doses above 100 mSv, through claims of "hormesis" below this dose. The victims must try to fit their problems into the narrow categories "accepted" by the ICRP. It should be the other way around, namely the ICRP is expected to recognize and protect against all mechanisms, damage to all important molecules, and the serious consequences of such damage for human health subsequent to all doses of radiation (Bertell, February 1998).

The illnesses brought back from the Gulf War and the illnesses emerging among populations in areas bombed by uranium/depleted uranium weapons cover a wide range. And yet, the powers that be are trying once again to frame the discussion of the safety of uranium weapons in terms of fatal cancers. The following quotations provide evidence of this maneuver:

Department of Health and Human Services, Agency for Toxic Substances and Disease Registry (ATSDR) in 1999 Toxicological Profile for Uranium. "*No human cancer of any type has ever been seen as a result of exposure to natural or depleted uranium.*"

United Kingdom Royal Society in May 2001. "Even if the estimates of risk are 100 times too low, it is unlikely that any excess of fatal cancer would be detected within a group of 10,000 soldiers followed over 50 years."

European Commission March, 2001 report. "Taking into account the pathways and realistic scenarios of human exposure, radiological exposure to depleted uranium

could not cause a detectable effect on human health (e.g. cancer)."

World Health Organization April, 2001 report. "The radiological hazard is likely to be very small. No increase of leukemia or other cancers has been established following exposure to uranium or DU."

European Parliament April, 2001 report. "The fact that there is no evidence of an association between exposures — sometimes high and lasting since the beginning of the uranium industry — and health damages such as bone cancer, lymphatic or other forms of leukemia shows that these diseases as a consequence of an uranium exposure are either not present or very exceptional."

There is a subtle and devious obfuscation of the matter at work in these official pronouncements. All of the "august" bodies quoted, and many more besides, reinforce each other in *confining* the discussion of the potential deleterious effects of uranium's radioactivity to the induction of fatal cancers. By resorting to this gambit, these organizations ensure that the battle about the hazards of uranium weaponry is fought on familiar ground. The nuclear establishment has successfully used this tactic for well over half a century to limit the public's perception of the hazards posed by nuclear weapons and nuclear reactors.

A stunning admission appearing in an article published by Sandia National Laboratory clearly demonstrates that, contrary to all the propaganda, researchers within government are fully aware that radiation produces significant non-cancerous effects and that these are a factor in the illnesses suffered by Gulf War veterans:

> "Helping Gulf War victims" – Sandia has been doing research on the role of mitochondria malfunctions identified as the most immediate cause of Parkinson's, Huntington's, and Alzheimer's. Loss of brain function is caused by neurons killed by malfunctions in the mitochondria. "**Malfunctioning mitochondria have also been linked to battlefield aftereffects caused by radiation** [emphasis added] or by nerve agents like sarin." Gulf War victims frequently develop Lou Gehrig's disease or "ALS (the neuron disease amytrophic lateral sclerosis) which is a neurodegenerative disorder that kills motor neurons causing paralysis and death in three years." It affects both Gulf War veterans and civilians. Funding is now being requested from the US Congress for research "to help Gulf War victims" (Singer; also Moret).

Rosalie Bertell has drawn attention to the fact that diabetes has been ignored as a possible endpoint of radiation exposure:

> Hiroshima and Nagasaki studies of non-cancer effects of exposure to ionizing radiation are either very poor or nonexistent. I remember my frustration when I first looked for data on the relationship between exposure to radiation and adult onset diabetes. Diabetes among Hiroshima males had shown a linear trend with dose for causing death (Beebe). Since diabetes is not normally a first cause of death, one could well question the relationship of radiation with incidence rate of diabetes. When I located the research paper from the ABCC, I was astonished to find a bold statement that diabetes shows no relationship with radiation exposure in the early part of the paper. There is no supporting evidence for this statement. The remainder of the paper is devoted to a discussion of diabetes among A-bomb survivors with no further mention of or reporting of their doses. Reference is made to negative findings of atomic bomb research in order to discourage further research into the relationship between diabetes and radiation. Diabetes rates are extremely high in the nuclear fallout areas of the Pacific, downwind of the Nevada Test Site, and in areas of heavy fallout in the Arctic. However, no research has been done into the possible causal links with nuclear fallout (Bertell, February 1998).

An honest assessment of the impact to health of scattering radioactivity into the environment must look beyond fatal cancers. This is the position of the newly formed European Committee on Radiation Risk:

> The Committee considers that the ICRP's concentration on fatal cancer as the main outcome of radiation exposure is inadequate for the purposes of protection of the public. The fundamental biological mechanisms of radiation action are now well established, and these clearly predict general harm to the organism at all doses. DNA damage to cells, which occurs at the lowest doses and which may become enhanced through a number of mechanisms not addressed by ICRP, must cause general and specific health detriment to the organism, even if this is not measurable epidemiologically (ECRR).

In concert with this opinion is the following observation by Chris Busby:

> There are many consequences of the irradiation of cells. These include cell death, mutation leading to dysfunction and mutation lead-

> ing to tumor and cancer. In the lifespan of humans, these results will show themselves as a very wide range of conditions. These will begin with infant and perinatal mortality, congenital abnormality and fetal development problems. They will include diseases which follow continuous stresses on vital organs, heart, brain, stomach, kidney and immune system. There will be increases in genetic based diseases like diabetes. All these will feed back on the organism's ability to survive any of the other illnesses, and the general effect will show itself as an increase in morbidity from all causes, with a lowering of the vital signs of populations such as infant mortality indicators and lifespan. The ICRP and other radiation risk models only address cancer as an indicator of the effects of radiation. However, the responses of populations all over the world to the global weapons fallout, and in particular the increases in infant mortality produced by the internal average radiation doses of about 1 mSv from these isotopes, show how sensitive the human organism is to internal radiation [Busby 1995]. Sharp depression in the birth rate was seen in many countries in Europe exposed to the radiation from Chernobyl, and there were increases in low birth- weight babies reported in many parts of the world [Busby 1995]. Despite this, no attempt has been made by ICRP or other risk agencies to examine non-cancer effects (Busby 2001, On Internal Irradiation).

Important non-cancer effects currently ignored by the "radiation protection" community are the health impact of radiation damage to germ cells expressed in the next generation:

> When the unrepaired or misrepaired damage due to radiation occurs in the germ cells, sperm (and stem cells which produce sperm) or ovum, that damage will be incorporated into every cell of the offspring made from that damaged DNA. It may show up as a miscarriage, stillbirth, teen age cancer or mid-life heart disease, but these are not considered to be "detriments" — another value judgment and not a scientific fact. Elimination of regulatory concern for diseases in offspring which are multifactorial reduced the number of genetic effects which would be counted. Even cancer and heart disease in offspring were eliminated. Guidelines today include only dominant and sex-linked chromosomal damage, and polyploidy, obvious from birth (Bertell 1998b).

In its first report, the ECRR presented the non-cancer risks associated with exposure to ionizing radiation that have been scientifically investigated. These included:

(1) Broad spectrum health detriment following exposure to low-level radiation. (2) Depression in birth rates. (3) Defects in fetal development. (4) Presumed increase in fetal death rates (although no figures exist for this effect.) (5) Infant mortality. (6) Decline in quality of life. (7) Reduction in lifespan. (8) Cardiac arrhythmias in children contaminated by cesium-137 from the accident at Chernobyl. (9) Reduction in IQ and performance test scores among children. (10) Accelerated aging as evidenced by the accumulation of somatic genetic damage, e.g. chromosome aberrations.

Research conducted in 1986 by the Investigative Committee of Atomic Bomb Victims of Hannan Chuo Hospital in Osaka, Japan, yielded similar conclusions, that there are other endpoints besides fatal cancers that need to be considered when evaluating the impact of ionizing radiation on populations. The illnesses suffered by 1,233 atomic bomb survivors with an average age of 59.5 years was compared to the expected level of the same diseases for a similar age group from the general population as reported by the Japanese Ministry of Health 1986 Report. The rates of illness in the study group compared to that of the control group are reproduced in the table below..

Ratio Between Illness in Atomic Bomb Survivors and that in the General Japanese Public of the same Age Group (Bertell 1998b.)

Disease	Incidence Relative Morbidity in A-Bomb Survivors
Leukopenia	13.4
Liver Disease	6.4
Eye Disease	5.0
Neuralgia and Myalgia	4.7
Ischemic Heart Disease	4.7
Gastro-duodenal Ulcer	4.7
Gastritis	4.5
Lumbago	3.6
Diabetes	2.7
Hypertension	1.7

A similar research effort conducted by Furitsu, cited by the ECRR, compared morbidity rates of non-cancer diseases in atomic bomb survivors in Japan with those in the general Japanese population. Bomb victims manifested considerably higher rates of a number of diseases as is evidenced in the table.

Comparison of Morbidity Rates (%) of the A-Bomb Victims and of the General Japanese Population (Furitsu, 1994)

Non-cancer Disease	A-Bomb Victim Sample Morbidity Rate %	Japanese Population Morbidity Rate %
Lumbago	29	8
Hypertension	24	15
Eye Disease	18	3
Neuralgia, Myalgia	12	2.5
Anemia, Leukopenia	12	1
Dental Disease	10	<1
Gastro-duodenal Ulcer	9	2
Ischemic Heart Disease	9	2
Liver Disease	8	1
Diabetes Mellitus	7	3
Nephritis, Urethral Infection	5	1
Skin Disease	5	2
Bronchitis, Pneumonia	5	0.8
Cardiac Arrhythmia	5	<0.1
Cholethiasis, Pancreatitis	4	1

(Reproduced from the 2003 Recommendations of the European Committee on Radiation Risk)

In the aftermath of Chernobyl, research uncovered serious systemic conditions produced by radioactive cesium:

> Important measurements of various indicators of health and biological parameters have been made by Bandashevsky. He has shown that various serious conditions result from internal exposure to Cesium. For example, there are degenerative heart conditions as shown by heart muscle conduction anomalies amongst children and students from the Gomel region of Belarus. For children under 14 living in the contaminated region, with an average body activity of 30 Bq/kg, between 55 and 98% have cardiac activity disorders. For students aged 18 to 20 years, there were 48.7% who showed pronounced ECG modifications. The average Cesium activity in these young people was 26 Bq/kg. The dose response relationship was also significant. Children with different doses of Cs-137 also showed dose-dependent increases in arterial blood pressure. About 41% of children from the contaminated region showed symptoms of arterial hypertension. Bandashevsky also shows effects of internal contamination on increases in illness and biological indicators of illness for diseases of the kidney, liver, immune system, eye, brain and nervous system and blood [Bandashevsky, 2000] (Busby 2001, On Internal Irradiation).

The ECRR reviewed a post-Chernobyl study by Malko who researched the rate of somatic illnesses in adults, adolescents and children in three contaminated districts and five control districts of the Brest region in Belarus. The incidence of a wide variety of non-cancer somatic illnesses was dramatically higher in the contaminated districts. These included: (1) Infections and parasites. (2) Endocrine disorders affecting metabolism and immunity. (3) Psychiatric disorders. (4) Chronic otitis. (5) Hypertension and ischemic heart disease. (6) Cerebrovascular disease. (7) Respiratory illnesses. (8) Diseases of the digestive organs including ulcers, gallstones and gallbladder inflammation. (9) Diseases of the urogenital systems including nephritis, nephrosis and kidney infections. (10) Problems with female infertility. (11) Skin diseases such as dermatitis and eczema. (12) Osteomuscular disorders and osteoarthritis.

The studies by Malko and Furitsu show many similarities. They testify to the fact that populations exposed to ionizing radiation manifest a broad spectrum of health detriments at rates higher than in suitable control populations. Further, this work suggests that the extent of the health effects from aboveground weapon testing and from both planned and unplanned radiation releases from commercial nuclear power plants and weapon production facilities has been dramatically greater than ever before imagined. The emphasis

on the induction of fatal cancers has masked these effects and discouraged serious investigation into the full range of disabilities inflicted on populations around the globe. Until the stranglehold on the discussion of radiation effects is broken, an honest assessment of the health impact from nuclear weapons and reactors cannot be attained.

Now it can be told why depleted uranium weapons represent such a contentious flashpoint. The deployment of these munitions represents the first time in history of the mass contamination of populations by a single radionuclide. Never before have sufficient numbers of people received into their bodies the same radioactive pollutant so as to enable science to determine the impact to health of low levels of internal exposure. The creation of this cohort of victims represents the greatest threat to the nuclear programs of government that has ever existed and explains why every effort is being made to hinder medical investigation of ailing veterans and to cover up the radiotoxicology of uranium. The victims of weaponized uranium have proven to be the proverbial canary in the coal mine. Uranium is of low radioactivity. Yet, significant numbers of veterans and "enemy" civilians are manifesting a variety of illnesses never before associated with such low-level exposure to ionizing radiation. Inadvertently, the United States has trapped itself in a web of its own making. It has created a huge laboratory of victims contaminated with uranium who are being studied by independent investigators from all over the world. And what is being witnessed is an overall debilitation in health of the exposed populations. Before all of humankind, the suffering of those contaminated by depleted uranium weapons is testimony against the lie formulated by the developers of nuclear weapons and reactors — that low-level radiation is not a hazard to health.

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Radiation Safety in Its Infancy: 1895 - 1953

Some facts are incontrovertible. For one, cancer is monoclonal. It arises from the mutation of a single cell. Cancerous tissue bears witness to this fact. All the cells are genetically identical, exact copies of the original altered cell. Also incontestable is that ionizing radiation is mutagenic. Atoms undergoing radioactive decay while embedded in the human body have the capacity to induce structural alterations in a DNA molecule, which in turn can lead to altered cellular function. Occurring at critical points along a DNA sequence, this mutation may be the precursor to eventual uncontrolled cell replication and the development of a cancer.

The Cult of Nuclearists, in defiance of these basic facts, promulgates the idea that the emission of radioactivity into the environment is a benign activity. They pitch to the world in classic doublespeak that *radioactivity does not create a radiological hazard*. This untenable position is the cornerstone of their ongoing enterprise. After each release of radiation into the biosphere, a disinformation campaign must be mounted to allay public concerns that a hazard, which does in fact exist, does not exist. The nature of the phenomenon forces the Cult of Nuclearists into this compromised position. They are at a loss to find any other way to juggle their agenda with basic scientific realities. Thus, their ongoing existence relies on deception. If the facts were known, the majority of the people would reject nuclear power plants, nuclear weapons, and radiological weapons as being too fraught with biological hazards. The banishment of these technologies from the earth would assuredly follow. To prevent this democratic decision from materializing, control of the nuclear game plan must be centralized. This pits the interests of the few against the interests of everyone else. Nuclearism can thrive only in an oligarchy, and so it does, despite our illusions of living in a democracy.

Radiation Safety in Its Infancy: 1895-1953

Buried in the heart of the nuclear age is a dirty little secret. So momentous is this secret that the ruling elite, empowered by their nuclear and radiological weapons, will resort to any treachery to keep it concealed. As long as it remains hidden, the most heinous crime in the history of humanity can continue undetected.[1] Once revealed to the light of day, a slumbering humanity will awaken to the painful realization that it has been duped and victimized. By artful deceit, the entire species has been betrayed, and the biological health of the planet has been jeopardized. Hyperbole is impotent to give true dimension to the magnitude of the fraud that has been perpetrated. So appalling is this crime that has swallowed up the earth that the writer's craft is made feeble to capture the breadth of the malfeasance that has been at work.

The key to this iniquity lies buried in the minutia of radiation biology. The official agencies that set standards for radiation safety have artfully manipulated the pivotal concepts of *dose* and *risk* to perpetuate an archaic and inaccurate understanding of radiation effects. In so doing, these organizations, to which the whole world turns for guidelines, promulgates as safe levels of exposure to radionuclides which are hazardous. This intentional corruption of scientific fact is what has allowed the nuclear establishment to pursue its agenda with impunity while leaving in its wake an epidemic of ailing victims whose health has been destroyed by internal contamination. The fact that the health physics community, which takes it upon itself to protect the public from the harmful effects of radiation, has permitted this infamy is self-damning, and serves as evidence that the discipline has been infiltrated and its integrity compromised by a political agenda.

The scattering of radioactivity over the earth, over the domain of life, creates a host of complex phenomena that impact on biological systems. Due to the complexities of

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[1] *Wings of Death: Nuclear Pollution and Human Health* written by Chris Busby was the original source of the core ideas of this chapter and the next relating to the profound mischief afoot in the field of radiation protection. Mr. Busby states:

"The fight of the dial-painters against the US Radium Corporation for recognition and recompense has become the fight of humanity against the nuclear establishment. As a consequence of the systematic pollution of the earth by radioisotopes, which as early as 1957 — only 12 years into the nuclear age — were to be found in all living tissue, in all people from Inuit and Lapp to Polynesians and Kalahari bushmen, we are all of us dial-painters, we are all victims of the greatest public health scandal since civilization began."

These words are not embellishment of the facts for dramatic purposes. If anything, they are understatement. What has transpired under the guise of radiation protection over the last half century is shocking. It is a story that needs to be told again and again until all people of the earth awaken to what has transpired. Humanity, and all creatures of the earth, have been victimized by a small cadre imposing on the earth their nuclear programs. And they have erected, like a smokescreen, a monumental deception to prevent recognition of their deeds. The historical record must be put straight so those who inherit the earth in our wake understand the origin of the radiological degradation of their planet and the criminals who performed it.

nuclear physics and radiation biology, average citizens have been forced to cede their innate caution and entrust their welfare to trained professionals, international regulating bodies, and the authors of government statutes. The public trusts that this bulwark has been erected for their benefit, that it protects them and their children from any abuses carried out by those in a position to expose them to health-damaging levels of ionizing radiation. The human community has skittishly acceded to the development of nuclear weapons, nuclear power and now radiological weapons only because of its naive belief that its welfare is being guarded.

A common thread runs through the history of radiation accidents and intentional releases of radioactivity into the environment. At some point after the event, the airwaves and media ring with a familiar litany: "The public has no need for concern. According to currently accepted international standards of radiation safety and risk assessment, the radiation released was in levels too low to create any adverse effects to health." This is the mantra of the Cult of Nuclearists. It's a pretty impressive statement. How can one argue with it? Anyone wishing to detract from official pronouncements regarding dispersed radioactivity doesn't seem to have a leg to stand on. To question the official version of events is to call into question the entire basis of radiation safety and the revered tomes published by highly respected international committees that dictate to the world the standards on which radiation safety is based. And yet, this is where the jokers in the deck are buried.

Radiotoxicology, the study of the toxic effects of radiation on living systems, has been the central discipline in all radiation research over the last century, at least among conscientious scientists. Early investigators discovered that x-rays and radioactivity were hazardous to health almost at the same time as these phenomena were discovered to exist. In order to safely study these wonders and apply them for the benefit of mankind, the fundamental priority among researchers became the determination of what constituted a non-hazardous dosage of radiation. When it was discovered that no dose of radiation existed that did not present some risk, efforts, at least in the biological sciences, were centered on reducing exposure to the lowest levels achievable. Guided by this principle, every advance in applied nuclear physics, radiology, tracer chemistry, radiation therapy, nuclear medicine, and so forth was accompanied by research designed to determine the safest methods of applying these technologies. The reigning ethic was respect for ionizing radiation's capacity to disrupt normal physiology. The goal was to reduce the amount of radiation received by researchers, medical staff and patients to the absolute minimum while still being able to achieve the sought-after result.

This fundamental principle of radiotoxicology was violently repudiated when physics was invaded and conquered by an army of barbarians unschooled in biology and unwilling to submit to ionizing radiation's power to alter healthy functioning in living sys-

tems. In their eyes, all that mattered was their own will to power. To hell with the health of the planet and the sanctity of Life. They terrorized everyone upon the earth with their cataclysmic detonations and the threat of annihilating all that the rest of humanity holds dear. They created mountains of radioactive waste impossible to dispose of. They sacrificed the health of unsuspecting unfortunates whose only crime was to seek employment in their industries or live downwind of their reactors and laboratories. Bearing testimony of their triumph over the earth, every living creature on the planet pays tribute to their conquerors by carrying within their molecular structure artificial radionuclides created in man-made radioactive infernos and discharged over the earth.

With Hiroshima and Nagasaki, the people of the earth were thrown into a new world, one not of their choosing. Nuclear technology, accompanied by the dispersal of unimaginable quantities of radioactivity into the biosphere, was imposed on the world by a handful of human beings, and the rest of humanity everywhere was forced to learn to live with it. Despite hollow government reassurances of stringent oversight and uncompromising safety standards, the public has remained wary of the nuclear behemoth. How could all be well with nuclear weapons exploding in the biosphere, radioactive offal spewing forth from weapons laboratories, and plumes of radionuclides escaping nuclear power plants? The entire enterprise has been dubious at best. Something, somewhere, has been fundamentally amiss, but nobody until now has been able to identify how the game has been so successfully rigged.

The people of this country have always had an intuitive recognition of the dangers of nuclearism, as evidenced by the periodic waves of agitation that have swept through the population. Worldwide protestation surfaced during the second half of the 1950s over weapon testing in the atmosphere. Similarly, grassroots opposition ignited over the siting and licensing of nuclear power stations and radioactive waste repositories. The ire of the civilian population was further raised as anecdotal evidence repeatedly surfaced of contamination and illness among GIs on maneuvers during weapons tests, downwinders of the Nevada Test Site, nuclear workers and residents dwelling in proximity to nuclear power reactors and weapons laboratories. And then there was Chernobyl, which unabashedly clarified for the whole world the true meaning of a nuclear catastrophe.[2]

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[2] As an aside, it is interesting to note that the Chernobyl accident is mentioned in the Book of Revelations of the *New Testament*. In that scripture, the following verses appear:

> "And the third angel sounded, and there fell a great star from heaven, burning as it were a lamp, and it fell upon the third part of the rivers, and upon the fountains of waters;
> And the name of the star is called Wormwood: and the third part of the waters became wormwood; and many men died of the waters, because they were made bitter." (viii:10-11)

What is this star called Wormwood that fell from the heavens and made bitter the waters? Wormwood is a general name given to any plant of the genus Artemisia. It is a bitter aromatic herb that makes bitter that to which it is added. The word for wormwood in Russian is pronounced *cherno-bee-el*. The accident at Chernobyl was a striking and chilling valiadation of the scriptures of old.

Despite all of this evidence as to the recklessness of technologies that release radiation into the environment, all opposition to them has been successfully repelled. Testimony by eminent scientists in the pocket of the nuclear establishment coupled with the mighty volumes of research they produced forever beguiled the better judgment of the people of the earth. Somehow the game was rigged. The ongoing conundrum has been to figure out how.

At some moment in the thirsty drive to create weapons of unlimited destructiveness and abundant electricity too cheap to meter, overseers of the development of these technologies realized that adherence to the rudiments of radiation safety as practiced in the biological sciences was impossible. But rather than abandon their quest for absolute power over all the earth and the centralized control of electricity production, they forged a giant lie to divert attention from the radiological degradation of life that was leaching across the planet. This lie was a work of art. It had to be. Mere misrepresentation of fact would be transparent and readily discernible to scientifically astute opponents. What was required was a subtle, imperceptible lie of momentous proportions that would skew forever the debate over nuclear technologies in favor of those who were profiting handsomely by them. By a deft sleight of hand, this big lie was implanted within the international standards by which the safety of us all from ionizing radiation is regulated. Persisting undisturbed up to the present, this lie is now being used to falsely corroborate the claim that contamination of the earth by uranium and depleted uranium weapons is without hazard.

To glimpse the villainy lying buried in the heart of the nuclear age, it is necessary to briefly review the history of radiation safety as it developed throughout the twentieth century. It is here in this arcane subject, interesting and accessible to only a small cadre of technocrats, that evidence of the most notorious deception in the history of humanity can be found.

The Discovery of X-Rays

The Nuclear Age began quite innocently and unexpectedly on the evening of November 8, 1895. In Würzburg, Germany, Wilhelm Conrad Roentgen was tinkering in his lab He was exploring the effects of propagating a stream of electrons, known then as cathode rays, through a Crookes tube, a glass tube from which much of the enclosed air had been removed. At one point, he covered the tube with lightproof cardboard, darkened the room, and turned on the apparatus. At that serendipitous moment, Roentgen noticed out of the corner of his eye a mysterious glow across the room on a piece of paper coated with a layer of fluorescent barium salt. Unsure of the source of the mysterious light, he turned

off his equipment. The scintillation ceased. With the equipment turned on once again, the luminescence reappeared. Meditating on the unaccountable observation, Roentgen concluded that some unknown type of energy was being created within the tube that had the capacity to pass through the opaque cardboard and traverse space. For the next five weeks, Roentgen exhaustively studied the nature of his discovery. He camped out in his lab day and night, having all his meals brought to him. By the end of his contemplative retreat, he had discovered all the major characteristics of the new form of energy. For this inscrutable phenomenon, he coined the name "x-rays." On December 22, in a moment of fortuitous whimsy, Roentgen summoned his wife to his lab and had her impose her hand between the discharge tube and a photographic plate. What greeted him when he developed the film was a wondrous sight. The shadows captured on the film clearly depicted the internal bony structure of his wife's hand. In that instant, a medical revolution was born.

Roentgen published his article "On a New Kind of Ray" at the end of December. Practically overnight, a "Roentgen mania" began sweeping through Europe and North America. On hearing of the discovery, amateur and professional researchers rushed to explore the intriguing possibilities inherent in Roentgen's mysterious rays. Within just a few months of their discovery, x-rays were being used in an amazing variety of applications. Industrial radiography was born when x-rays were used to image the integrity of welds. Physicians produced radiographs to help locate shrapnel in wounds and provide a guide for the setting of broken bones. X-ray images were used in obstetrics to detect multiple births, reveal abnormal uterine conditions, and outline the pelvis to assist in delivery. Imaging the body's interior became an important diagnostic tool for a variety of conditions such as tuberculosis, pneumonia, and the enlargement of heart and spleen. Enchantment with the mysterious energy led physicians to improvise medical treatments to explore the effects of x-rays on diseased tissue. Just four weeks after Roentgen's discovery, Dr. Emil H. Grubbe of Chicago used exposure to x-rays as a treatment for a woman suffering from breast cancer.

X-rays rapidly gained a reputation for being a miracle cure for a host of ailments. They were used to arrest the development of growths and tumors. They became part of the treatment regime for painful inflammations, tuberculosis, asthma, whooping cough, and a host of other illnesses. Numerous skin diseases, including acne, ringworm, eczema and psoriasis were targeted with the new energy. In the course of exploring the therapeutic application of x-rays, physicians came to believe that as many as a hundred diseases were treatable by irradiation. Thus began a craze, that continued for well over forty years, of prescribing x-ray treatments for a wide variety of medical conditions. Only belatedly was the discovery made that countless numbers of patients had been transformed into unwitting victims, suffering from radiation-induced injuries and malignancies.

Within a few months of Roentgen's initial announcement, the miraculous promise of the newly discovered energy began to be haunted by an unanticipated dark side. In 1896, Dr. D.W. Gage of McCook, Nebraska noted that x-ray exposure had the potential to produce hair loss, skin reddening, a sloughing off of skin and other skin lesions. Other investigators reported that x-rays had the capacity to cause burns and ulcerations that refused to heal. By the end of the first year of experimentation, the scientific journals had reported twenty-three cases of x-ray injury, mostly to radiologists and manufacturers of x-ray equipment. With the passage of time, instances of skin cancer were noted as well as cases of bone cancer that resulted in the amputation of fingers and hands. Sterility and damage to the blood-forming organs were other complications that were reported. By 1900, the number of "recorded" injuries had climbed to 170.

In the latter part of 1896, the physicist Elihu Thomson, who worked in the Schenectady, New York laboratory of General Electric, deliberately experimented on himself to objectively record the onset and development of x-ray burns. After exposing the little finger of his left hand to the penetrating rays, he set down the following observations: (1) X-rays caused tissue damage. (2) The amount of exposure determined the degree of the damage. (3) Some threshold existed beyond which the development of troublesome damage was inevitable. (4) The cumulative effect of several small doses of x-rays was equal in effect to exposure to one large dose. (5) The intensity of x-rays decreased as the square of the distance from the source increased. (6) An incubation period existed before x-ray injury became manifest.

The first death in the United States attributed to x-rays was of Clarence Madison Dally, a glassblower in Thomas Edison's Menlo Park laboratory. Dally made x-ray tubes and routinely gauged their output by inserting his hand into the path of the generated beam. With time, this habit, which became common practice among radiologists, caused ulcers to appear on both of his hands and arms. His hair fell out and lesions developed on his scalp. To halt the spread of a proliferating skin cancer, he underwent a number of amputations. After two years of battling his x-ray induced illness, Dally succumbed in 1904. His death was far from unique. During the annual meeting of the American Roentgen Ray Society in 1908, fifty cases of "poisoning" by x-rays was announced. Although the numerous reports of injury warranted caution, the invisible nature of x-rays and their delayed effects seduced radiologists into carelessness. Those who thought themselves immune to injury later painfully discovered the error of their ways.

As the 1920s dawned, a previously unanticipated hazard of x-ray exposure revealed itself. Leukemias and cancers, requiring a long period of latency to manifest, surfaced among the population of radiologists. A survey in 1922 estimated that a hundred radiolo-

gists had been martyred by their profession, dying of radiation-induced cancer. This type of injury was not confined to radiologists and their patients. With no regulation in place, x-ray machines were freely available to the general public. As an example, x-rays were widely used in beauty parlors to remove unwanted facial and body hair. The Tricho Institute, founded by Albert Geyser, popularized this treatment, leasing equipment and offering a two-week training course in its use. Many women, hoping to be beautified by x-rays, suffered horribly as a result, contracting painful radiodermatitis, burns, ulcerations and cancers. Thousands of women are thought to have suffered injury, malignancies and death as a result of this practice.

Besides these human guinea pigs, animal experimentation was carried out to detail the biological effects of x-rays. Early research conducted on frogs and tadpoles revealed that exposure to x-rays produced genetic defects and mutations. Systematically exploring this phenomenon, Hermann Muller irradiated a variety of species of plants and animals. In his most famous series of experiments, Muller exposed populations of fruit flies to different dosages of x-rays. His discovery was disturbing. The number of mutations observed was directly proportional to the amount of radiation received. *And, there was no lowest limit of exposure that was without mutational effects*. Contrary to the widespread belief of his day, Muller proved that no-threshold dose to genetic damage existed. As dosage of x-rays decreased, only the frequency of mutations decreased. No dose existed that was 100% free of risk. Muller's scientific work was published in 1927, and twenty years later he received the Nobel prize for this research.

The Development of the First Standards of Radiation Safety

As knowledge of the hazards of x-rays accumulated, it became an urgent priority among radiologists and researchers to develop safe operating guidelines and standards of protection. In pursuit of this goal, an ongoing debate arose between physical and biological scientists as to the best method of quantifying and measuring x-ray radiation. Physical scientists favored methods that involved observing and then grading the physical and chemical effects x-rays produced on different materials. A number of such systems of measurement were devised that relied on such things as the blackening of photographic film, color changes in certain chemicals, fluorescence in light-sensitive material, and the ionizations of gases. In marked contrast to this approach, physicians and researchers in the biological sciences favored measuring x-rays by their most obvious biological effects. They felt that this approach would allow them more accurately to anticipate the effects different levels of

exposure would have on patients.

During the first two decades of radiation research, the perspective of the biologists seemed to offer a more practical solution to the problem of gauging the impact of different levels of exposure. Thus, the first standards of radiation safety revolved around observable harm and injury. One measure was the "epilation dose," the amount of radiation necessary to induce hair loss in the exposed area of the body of the average patient. Trial and error relating the energy output of a machine to the delayed effects of hair loss eventually led to a determination of how much exposure was necessary to induce epilation. This knowledge allowed for the development of the radiometer. When placed halfway between the x-ray tube and the patient, the barium platino-cyanide contained in a small ampule changed color from bright green to orange indicating the epilation dose had been administered.

A different system of measurement which gained much wider use was also keyed to observable biological effects. The skin "erythema" dose became the amount of x-ray exposure sufficient to cause skin reddening. Larger or smaller dosages of radiation were then expressed as fractions or multiples of this quantity of radiation. Dosages small enough not to produce such visible effects were considered harmless. Although representing an advancement in radiation safety, this system was woefully imprecise. In her excellent history of radiation safety, *Multiple Exposures*: *Chronicles of the Radiation Age*, Catherine Caufield makes the following observations about the limitations of the erythema dose:

> For many years the erythema dose was the most popular measure of radiation, but it was an indirect and inexact measure. In the first place, the production of an erythema depends not only upon how much radiation a source emits, but upon many other factors as well, including the length of the exposure, the area exposed, the amount of shielding used, and the time elapsed between exposures. Secondly, individuals vary widely in their sensitivity to radiation. And thirdly, the word erythema meant different things to different people, anything from a relatively mild blistering to a severe inflammation lasting for several months. As a result, the amount of radiation required to cause erythema varied by as much as 1,000 per cent, depending upon the occasion, the subject, and the observer (Caufield).

Progress in radiation safety hinged on the thorny problem of what a "dose" of x-rays actually meant. This in turn was predicated on finding an accurate way objectively to measure and quantify x-ray energy. As an analogy, think of being in a dark room. You turn a flashlight on and then turn it off again. The question is: How much light was released

into the room? How do you measure the light energy at the surface of the flashlight, at any point along the path of the beam, and at the point where the light hits the wall?

In a brilliant leap of conceptualization, physicists addressing the problem realized that the transmission of x-rays could be interpreted by translating the phenomenon into the language of electricity and the propagation of an electrical current. It was known that x-rays, while propagating through air and other gases, ionized the molecules of the gas into positively and negatively charged particles. As a result, an electrical current could be induced within the gas. Further, the amount of ionization was proportional to the quantity of x-ray energy absorbed by the gaseous medium. As x-ray energy increased, so did the number of ions created. The greater the number of ions, the greater the strength of an electrical current. On the basis of this phenomenon, detection instruments were created that measured the energy of x-rays by displaying the strength of the electric current induced within an enclosed gas. Such tools paved the way for standardizing the concept of dosage. The output of different x-ray machines, the amount of this energy transmitted through the medium of the air, and the actual amount of energy reaching the skin of the patient were all variables which became intelligible, standardized, quantifiable and measurable upon relating them to the strength of the electrical current generated in a detection instrument.

In 1928, the International Congress of Radiology met in Stockholm and adopted the "roentgen," keyed to the amount of ionization in air, as the unit of measurement of x-ray exposure. The roentgen (represented by a lower case "r") is now defined as the quantity of energy carried by x-rays (or gamma rays) which produces 2.1 billion ion pairs in one cubic centimeter of dry air. Barton C. Hacker, in *The Dragon's Tail: Radiation Safety in the Manhattan Project, 1942-1946*, makes an important distinction about the roentgen that should be kept in mind: "Technically, the roentgen was a unit of exposure, not dose, but for the next three decades most workers ignored this subtle distinction" (Hacker 1987). In other words, measurements in roentgens were measurements of the quantity of ionization occurring in air external to the body. This gave a measure of how much energy the body was exposed to. It gave no information about how much energy was actually absorbed by tissue. Over time, radiologists compiled a body of knowledge that allowed them to correlate the amount of external exposure received by a patient with the biological effects created by that exposure. In this way, the roentgen became a useful measurement of dosage.

What finally led to the establishment of the first standards of safety for radiation exposure were studies undertaken to determine the quantity of x-ray energy needed to produce the observable biological effect of skin reddening. In 1924, Arthur Mutscheller, a physicist employed by a company that manufactured x-ray equipment, set out to determine

how much x-ray exposure a human being could "tolerate" without ill effects. Through his investigations, he concluded that a person would be safe from all injury if he did not receive within a thirty day period a dose greater than 1/100 of an erythema dose. In 1925, Rolf Sievert of Sweden advanced the idea that a safe level of exposure to ionizing radiation could be determined by comparing it to a person's annual exposure to natural background radiation, the radiation each of us receives annually while dwelling on planet earth as a result of cosmic rays and terrestrial radioactivity. Sievert estimated that the average dose that humans received naturally from the environment was between 0.001 and 0.0001 of an erythema dose. As a conjecture, not backed up by evidence or experimentation, he proposed that humans could safely receive 1/10 of an erythema dose from x-ray exposure without any hazard to themselves. A couple of years later, Alfred Barclay and Sydney Cox, two British physicists, made a study of two radiation workers who had worked for six years without incurring any ill effects. They calculated the amount of radiation the two had been exposed to, divided the amount by an arbitrary safety factor of their own devising, and concluded that a safe dosage of x-rays that could be tolerated yearly was 0.08 of an erythema dose.

These three studies produced approximately the same results. A safe dose was considered to be between 1/10 and 1/100 of an erythema dose. For the most part it was pure luck that the three were in such close harmony. None of the results were grounded in objective science. All were but educated guesses based on a number of unsubstantiated assumptions. Nonetheless, they provided a focus for zeroing in on what might be a reasonably safe exposure to x-rays. Eventually agreement was reached among researchers that 600r constituted one erythema dose. Relating this figure to Mutscheller's calculations, what appeared safe was a dose of no more than 6 roentgens per month or 0.24r per day.

When the International Congress of Radiology met in 1928, it established a committee to further the work of radiation safety. This committee became known as the International Committee on X-Ray and Radium Protection (ICRP). In the following year, a similar committee was formed in the United States, the United States Advisory Committee on X-Ray and Radium Protection. This committee consisted of eight members: a physicist and radiologist from the American Roentgen Ray Society, a physicist and radiologist from the Radiological Society of North America, a spokesman for the American Medical Association, and two representatives from x-ray equipment manufacturers. The work of establishing worldwide standards for radiation safety was initiated and perpetuated by the US Advisory Committee and the ICRP.

Lauriston Taylor became a pivotal figure in the history of radiation safety. He

received a B.A. in physics from Cornell University and then joined the National Bureau of Standards in 1927. He was the US representative to the 1928 meeting of the ICRP. This position, in turn, led to his becoming chairman of the US Advisory Committee the following year. In 1933, he advocated for the US Advisory Committee to adopt the tolerance dose for x-rays propounded by Mutscheller. After much discussion, Mutscheller's limit of 0.24r per day was rounded down to 0.1r. As mentioned in *Multiple Exposures*: "Using the higher figure, they feared, would, in Taylor's words, 'appear to be implying an unreasonable knowledge of the subject'" In March of 1934, the Committee officially adopted 0.1r per day as the first standard for radiation exposure.[3] A warning accompanied this standard: "Too great reliance is not to be put on the above figures" (Hacker 1987). Four months later, the ICRP rounded off Mutscheller's calculations to 0.2r per day and adopted that as its recommended standard for safety.

The adoption of these first standards for irradiation to the exterior of the body by x-rays was an important milestone for radiation research. However, drawbacks accompanied this tentative success.

> The 1934 standards set radiation protection on a new path. Internationally agreed, authoritative, precise, they inspired confidence. Today's protection standards are their direct descendants. But, as a close inspection of their development reveals, those first standards rested on scientifically shaky ground — on studies too short to detect long-term effects; on inadequate samples; on ill-defined and inconsistent units of measurement; on untested assumptions. 'Mutscheller's work', says Lauriston Taylor, 'was seriously flawed, and yet that is still the basis for our protection standards of today. It really is' (Caufield).
>
> These 1934 standards were sold as being based on a scientifically backed, reasonably precise understanding of the effects of ionizing radiation. They were, in reality, guesses based on inadequate research of overt and gross effects and involving total disregard of the increasing evidence for serious long-term mutation-related problems like cancer. They were based on inadequate sampling, untested assump-

[3] The established standard for x-ray exposure was also applied to exposure to gamma rays. In 1900, the French scientist Paul Villard established that a component of "uranium rays" was an energy similar to x-rays. Ernest Rutherford named this energy *gamma* rays. Gamma rays, like x-rays, represent a range of frequencies of electromagnetic energy. Their wavelength is shorter than that of x-rays, their frequency is greater, and their energy is greater. Gamma rays are emitted from the nuclei of atoms and are emitted either alone or in conjunction with alpha and beta particles at the moment of radioactive decay of an atom.

> tions, and on physical models for radiation which were, then as now, far too crude to describe the biological effects of ionizing radiation (Busby 1995).

To digress momentarily, the following point deserves mention. When first investigating the biological effects of ionizing radiation, researchers set out to determine the amount of radiation the human body could safely absorb without sustaining any ill effects. What they sought was the "threshold dose," the dose below which absolute safety was assured. After Muller's discovery that no amount of absorbed radiation was without the risk of genetic mutation, it became apparent that the paradigm of a threshold necessary for radiation injury was no longer valid. Summarily, the concept was rejected as ill-conceived, and what arose to take its place was the idea of the "tolerance dose." Within this framework, the effects of radiation were considered analogous to that of poisons and other toxic agents. Exposure to these in low doses caused no apparent damage. If undetectable damage was nevertheless incurred, the target organ or tissue had sufficient opportunity to repair itself without deleterious effects to the whole organism. Apparently, some level of toxicity was tolerable to the body without its sustaining injury or long-term pathology. Radiation safety thus required a determination of what that level was for the average person. Implicit within this conceptual framework of the tolerance dose was the idea that those being exposed to radiation had to accept some minimal risk to their health. Since absolute safety was impossible, radiation protection was based on striking a balance between the degree of safety achievable and the cost of providing it. Mutscheller's work provided an example of this tradeoff. "The exact thickness of lead required to reduce the computed unshielded dose to the tolerance dose was read from a table based on the fraction of X rays lead absorbed at various wavelengths. If cost, weight, and use permitted, shielding might be increased, but the table gave 'the permissible minimum thickness of protective material.' Thus were cost and safety balanced" (Hacker 1987).

By 1941, the US Advisory Committee realized that there were insurmountable problems inherent in the idea of tolerance. The major drawback was that no scientific proof existed to validate its accuracy as a model of how radiation actually affected the human body. Further, people were wrongly interpreting the tolerance dose as representing a completely safe dose which was never the intended meaning. At a meeting in September, the recommendation was made that proposed guidelines for radiation safety would henceforth be put in terms of the permissible dose. As stated then of the permissible dose: "This does not in any way imply that no injury will follow. It merely says that the Committee recommends its use even though it is not necessarily safe, but is adopted only as a practical and expedient value" (Hacker 1987).

Practical for whom? Expedient for whom?

The concept of the permissible dose has guided all subsequent development of radi-

ation standards of safety. Embedded within it is the idea expressed by the Committee in 1941: The standards recommended by regulatory agencies are not to be understood as representing safe dosages; they are adopted only as a practical and expedient values. What are deemed permissible levels of irradiation and internal contamination are value judgments. These value judgments, upon which the health and safety of all mankind relies, are formulated by a small fraternity of advisors, frequently with ties to government and the nuclear industries. As such, in any discussion of radiation safety, the following questions deserve legitimate consideration: Who says a particular dosage of radiation is permissible? What is their basis for claiming that it is permissible? How do those who recommend it personally benefit by saying that it is permissible? Who stands to benefit financially from the recommendation? What are the benefits for those who actually receive the radiation dosage? What risks to their health do they incur by allowing themselves to receive the permissible dosage? Consideration of these questions are equally important for the woman weighing the hazards of receiving radiation therapy for her breast cancer as it is for citizens debating the wisdom of their government dropping uranium weapons on foreign populations.

To return to the historical narrative, during the 1920s and 1930s, many physicians came to dislike the concept of the tolerance dose and the computations that it required. The physics-based model of calculating dosage by measuring quantities of ionization was hard to bring into line with their actual experience of working with patients. For those trained in the biological sciences, the new standards were inadequate for gauging the effects of exposure to patients. As Hacker observed in *The Dragon's Tail*: "Many doctors still disliked the approach, which seemed too abstract and mathematical; they preferred erythema dose as more closely related to biological realities" (Hacker 1987). From experience, they knew that physically identical doses could produce markedly different effects in different individuals. This reality was not addressed by the new approach. Nevertheless, the physics-based model became the dominant model for measuring ionizing radiation and determining its effects.

Up to this point, the discussion has revolved around ionizing radiation in the form of x-rays and gamma rays as they impinge on the body from the outside. Humans also absorb radiation from radioactive substances that gain entrance to the internal environment of the body. An understanding of this qualitatively different phenomenon grew up simultaneously with that of x-rays during the early decades of the twentieth century.

The Discovery of Radioactivity

On January 20, 1896, Antoine-Henri Becquerel was sitting in the front row of a meeting of the French Academy of Sciences when news of Roentgen's discovery was presented. Afterwards, Becquerel approached Henri Poincare and asked him his opinion on the origin and nature of x-rays. Poincare replied that he believed that the x-rays from

Roentgen's experiments originated when the beam of cathode rays collided with the glass wall of the vacuum tube. Becquerel, who had already conducted in-depth studies into the phenomenon of fluorescence, like his father and grandfather before him, reasoned that perhaps the glass absorbed energy and then fluoresced x-rays in response. This idea piqued his interest, and he set about seeking other fluorescent materials that might similarly emit x-rays. The experimental method he devised was simple. He wrapped photographic plates in opaque black paper. Upon these he placed known fluorescent minerals and exposed them to the sun. If any absorbed sunlight and then emitted x-rays, Becquerel expected the evidence would appear as a darkened silhouette of the mineral sample on the developed image. In the course of his experiments, quite randomly, he selected to test a rare sample of uranium from his collection. To his satisfaction, after exposing the mineral to sunlight for a number of hours and developing the image, he observed, as predicted, a shadow picture in the same shape as the mineral sample. Becquerel thought he was onto a new source of x-rays.

Again, capricious serendipity opened doors to new knowledge. Becquerel made preparations to repeat his experiment, but alas, the skies became overcast for many days. Resigning himself to the forced delay, he put the wrapped photographic plate with the uranium sample upon it in a drawer and left it there for three days. On Sunday, March 1, Becquerel entered his lab, the skies still forbidding his research. Some whim took hold of him in his idle moments, and he decided to develop the photographic plate that had been locked away in the dark. What greeted his eyes left him dumbfounded. A silhouette of the mineral sample was etched on the plate, and the image was much sharper than when the uranium salts had been left in the sun for only a few hours. Becquerel knew he had discovered something new, and with the thrill of an explorer, conducted further investigations. On March 23, he announced at a meeting of the Academy that uranium emitted some unknown form of energy which darkened photographic plates and had the ability to ionize air.

In 1896, Marie Sklodowska Curie, at that time a student at the Sorbonne in Paris, heard of Becquerel's discovery and chose the study of "uranium rays" as the subject of her thesis. In the course of her early research, she discovered that the ore pitchblende, from which uranium was extracted, emitted four times as much energy as pure uranium alone. This led her to postulate that some other unidentified energy-emitting mineral lay hidden in the pitchblende. When chemical analysis failed to disclose the mineral, she reasoned that it existed in minute concentrations, and as a consequence, must be thousands of times more energetic than uranium. She published these findings in an article that appeared in April 1898. In that article, for the first time, appeared the word "radioactivity," the term Curie used to describe this new fundamental property of matter. In July, Marie and her husband Pierre discovered the element polonium. In December, they identified the element which

they sought: radium. It took four years of tedious work for them to isolate a minute amount of the new mineral; twelve years later they had a 0.0085 gram sample of pure metallic radium that proved 3 million times more radioactive than a similar-sized quantity of uranium.

No biological effects from radium were noted until April 1901 when Becquerel, carrying in his waistcoat pocket a sample he had borrowed from the Curies, received a burn to his skin (caused by the emission of gamma rays produced by radioactive decay). The physician whom he consulted pronounced that the injury appeared identical to that produced by x-rays. This observation suggested an intriguing possibility. If radium behaved like x-rays when brought into contact with human tissue, perhaps it possessed similar therapeutic properties. Following this line of inquiry, Pierre Curie was the first to observe that emissions from radium killed diseased cells in laboratory animals. He was also the first to witness that radium shared the malignant nature of x-ray exposure. After implanting a few milligrams of radium near the vertebral column of mice and guinea pigs, he witnessed that death followed within a short time. Pioneering investigation into the influence of radiation on embryonic development, Pierre Curie also discovered that, following exposure to radium, tadpole embryos exhibited anomalies.

The first documented medical procedure employing radium was performed in April 1901 when Alexandre Danlos and Eugene Bloch at the St. Louis Hospital in Paris used the radionuclide to destroy a tuberculous skin lesion. That cancers deep within the body could be successfully treated by radium was first suggested in 1903 by Alexander Graham Bell, the inventor of the telephone, when he put forth in a letter the idea that a tiny bit of radium could be sealed in glass and inserted into or near a tumor to kill the proliferating cells. Medical procedures employing radium evolved in stages. First, treatments consisted simply of placing a sample of radium on the external surface of the body either to treat skin lesions or to bring the radium into as close proximity as possible to some underlying subcutaneous pathology. With no scientific criteria to regulate these procedures, trial and error was the guiding methodology. Deleterious effects in the form of skin burns of various degrees of severity were not uncommon. The next evolutionary step in radium therapy was the insertion of sealed sources of radium into accessible body cavities to reach tumors and diseased tissues deeper within the body. Injecting radium chloride into the bloodstream soon followed, premised on the unfounded hope that the radium would positively affect systemic conditions or would find its way to diseased tissue and provide a beneficial result. The first published study on the intravenous injection of radium as a treatment for a host of diseases was authored by Frederick Proescher in 1913. In the years following, untold thousands of people suffering from a variety of illnesses with no known cure received radium injections. From 1914 until 1932, the internal use of radium was approved by the American Medical

Association. Virtually ignored was the case of a woman patient in Germany who, in May 1912, died after receiving injections of a radium isotope for the treatment of arthritis.

What propelled much of early radium therapy was a naive faith, rooted more in mystical belief than scientific thought, that the mysterious energy emanating from radium possessed curative properties. Reports from both doctors and patients attributed phenomenal results to the new experimental treatments. Reviewing the European literature in 1913, Drs. Rowntree and Baetjer of Johns Hopkins University discovered that of 1,038 patients reported to have been treated with radium, 837 — over 80% — reported benefits. Radium was the wonder drug of the era and became the treatment of choice for hundreds of different diseases. Dr. Harrison Standford Martland, of whom more will be said shortly, hypothesized a "false health" factor to internally introduced radium that goes a long way in explaining the radium health fad that continued into the early 1930s. He suggested that the feeling and appearance of vibrant health among those exposed to radium was in fact an early symptom of radiation poisoning due to the body's production of an abundance of red blood cells in response to the radiation's initial damage. The apparent good health was only a transitory stage on the way to serious debilitation. Time attested to the truth of this observation. As radium treatments proliferated, reports began appearing with increasing regularity of external burns suffered by both patients and physicians and, among patients administered radium internally, an unexplainable decline in overall health and well-being followed by extreme suffering and death. Among the many people receiving exposure to radium during the first three decades of the twentieth century, the greatest number of victims came from this cohort of patients treated with radium for medical purposes.

Internal exposure to radium was widespread in the second and third decade of the twentieth century due to the many radioactive remedies and tonics that became popular among the general population. How these gained a following makes for an interesting story. In 1903, water from wells in and around Cambridge, England was discovered to contain low levels of radioactivity. Further investigation throughout Europe and the United States identified a number of springs that emitted radioactivity, some of which contained radium and the element radon which had been discovered in 1900 by Friedrich Ernst Dorn. This naturally occurring radioactivity offered the perfect explanation as to why some of these springs had acquired the reputation for possessing healing properties and why great numbers of people traveled great distances to bathe in their waters. With radioactivity premised to be the curative agent, owners of the springs began to capitalize on the public's enchantment with radioactivity by bottling the water and selling it as a nostrum. One obstacle that needed to be overcome was the fact that any radon content in the water diminished over time, later understood to be the result of its radioactive decay. To bring the healing waters to a wider public, innovation was required. Thus was born the Revigorator, "the magic

jar", "the jar of life." Patented by the Radium Ore Revigorator Company of California on July 16, 1912, this invention consisted of a jar made of carnotite ore which steadily released radon into the contained water. After drinking this remedy, people reported miraculously experiencing relief from a variety of chronic ailments. As word spread and demand swelled, a number of companies began marketing radioactive water made by a variety of methods. In this way, health crocks, designed to add radioactivity to water, were a must-have appliance among health fanatics for the next twenty years. At the same time, radium-based remedies of all kinds began to flood the market. Charlatans hawked these products promising a cure for every conceivable condition. A radium craze gripped the popular imagination. Consumers could buy a slew of healthcare products containing or purporting to contain radium. A radioactive belt was available that could be worn across any part of the body that was in need of healing energy. There was radioactive toothpaste to brighten the smile and radioactive face cream to lighten the skin. A radioactive contraceptive jelly was marketed. And in Germany, a chocolate bar, containing a touch of radium, was sold as a rejuvenator.

Among the many radium waters, popularly referred to as "liquid sunshine", was an expensive brand called Radithor. In the time between 1925 to 1929, close to half a million bottles were sold. Radithor came in half-ounce bottles, each containing one microcurie[4] of radium-226 and one microcurie of radiothorium, radium-228. Among the many wealthy devotees of this popular elixir was a prominent steel tycoon from Pittsburgh by the name of Eben Byers, a much sought-after bachelor, man about town, and dedicated sportsman who in 1906 was National Amateur Golf Champion. Routinely, Byers would drink up to four bottles of Radithor a day, consuming several thousand bottles over a three-year period. Initially, he felt rejuvenated by the tonic, but with time his health began to fail and he progressively weakened. The radionuclides retained within his bones incrementally destroyed his bone marrow, and he became increasingly anemic. His kidneys progressively failed. Creeping necrosis of the jaw demanded several surgical interventions that eventually led to the removal of all of his upper and most of his lower jaw. Necrosis also began eating away at his cranium. Parts of his skull were surgically removed. In time a brain abscess developed. His hideous death in 1932 was widely publicized and provoked a national outcry against radium remedies. Frightened consumers, sobered by the hazards of internal exposure, for the most part turned their backs on radium products and brought about a collapse of the industry.

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[4] The *curie* is the old unit of measurement for radioactivity. It represents the rate of decay of one gram of radium which is 37 billion atomic disintegrations per second. Thus, a microcurie represents 37,000 disintegrations per second. The modern unit is the *bequerel*. One bequerel equals one disintegration. By this measure, the activity per second of radium is 37 billion bequerels.

The Development of the First Standards for Internal Contamination

It took a tragedy to precipitate the first serious scientific research into the physiological effects of radium and the development of the first safety standard for internal exposure to a radionuclide. As the 1920s dawned, a number of women employees of the US Radium Corporation in Orange, New Jersey began suffering symptoms of a mysterious malady. Their job was the meticulous application of radioluminescent, "glow-in-the-dark" paint to the numerals on watch faces and other instruments. To perform this fastidious work, these radium dial painters routinely sharpened the tips of their brushes by passing them between their lips. Each time, they ingested minute quantities of paint and microscopic quantities of radium. At first, the illnesses among these women were not recognized as originating from a common source. Each victim sought medical help from a different physician, totally unaware that fellow employees were similarly suffering. They were variously diagnosed with sepsis, anemia, angina, rheumatism and syphilis. Much later, when the scourge had been identified as a new occupational illness, the typical course of the affliction was charted. Those who became ill initially began to feel weak and out of sorts. This malaise was frequently accompanied by a toothache. After a woman sought out a dentist and had the problem tooth extracted, the socket refused to heal and continued to bleed. Infection set in. Ulcers developed and spread throughout the mouth. Necrosis of the jaw followed which required surgical removal of bone. This syndrome was accompanied by anemia and a severe drop in white blood cells. Physicians and dentists were completely baffled by the unusual progression of this unidentified disease. Finally in 1924, Dr. Theodor Blum, an oral surgeon from New York City, correctly diagnosed "radium jaw" as osteomyelitis induced from poisoning by a radioactive substance. (Some of the women also suffered and died from cholangiocarcinoma — cancer of the bile duct).

Between 1921 and 1924, nine women who had worked for US Radium were dead. By 1928, the death toll had risen to fifteen. This was just the first wave of suffering to sweep through the population of some 4,000 women employed as dial painters in fifty studios throughout the United States and Canada. Starting in 1929 and continuing for the next sixty years, an epidemic of osteogenic sarcomas and other cancers claimed many of their lives. Many who did not succumb to their radium poisoning developed a variety of chronic ailments. The last of 112 radium dial painters to die from complications arising directly from internal exposure to radium passed away in 1988. This cohort of women was studied extensively up to the last decade of the twentieth century and became an invaluable source of data on the effects to human beings of internal contamination.

After the first deaths of the radium dial painters, a number of investigators independently arrived at the same conclusion that radium poisoning was responsible for the

deteriorating health of the workers at US Radium. The company vehemently denied this claim, ascribing the illnesses to poor dental hygiene and hysteria. They steadfastly maintained that the quantity of radium in the paint, one part to 40,000 parts zinc sulphide and a binder, were too minute to be responsible for inducing serious illness. Before all detractors, they paraded the belief that ingested radium passed right through the digestive tract without being absorbed and was quickly eliminated. Further, they argued that the radiation of alpha particles emitted by radium could not possibly be dangerous because alpha particles were so weakly penetrating that they failed to pass through even the thin layers of the skin.

Dr. Harrison Martland, chief medical examiner of Essex County, New Jersey, performed much of the detective work that disproved the claims of US Radium and definitively established that exposure to radium in the workplace was responsible for the unusual pathology exhibited by the dial painters. Dr. Martland performed autopsies on some of the deceased women and was able to take tissue samples for both pathological and radiochemical analysis. In the course of his investigations, he discovered that ingested radium was not totally excreted by the body. A portion was retained and deposited in various tissues where it became a source of ongoing exposure to surrounding cells. Dr. Martland succeeded in accurately measuring the total body burden of radium retained in the bodies of the deceased and was the first to determine which organs accumulated the radionuclide and in what concentrations. In one autopsy which he performed in 1927, he discovered that a bone cancer had developed in a woman whose body burden of radium was only fifty micrograms. To verify and extend his research, Dr. Martland examined living dial painters. By having them exhale onto a zinc sulphide screen, which would scintillate when struck by radiation, he was able to detect the presence of radon-222, the decay product of radium, and radon-220, a decay product of mesothorium, a cheaper radionuclide than radium that was frequently substituted in the paint. To estimate total body burdens, he combined these findings with measurements of gamma emissions measured at the surface of the body with an electroscope and the results of analysis of the women's feces.

Dr. Martland followed the health of the dial painters for decades and published numerous articles on their fate. Writing in 1925, he called attention to the hazards of internally deposited radium and the long-term consequences of prolonged irradiation of the blood-forming organs. In 1929, the conclusion of an article contained the observation that "alpha particles are probably the most potent and destructive agent known to science" (Martland 1929). A 1931 article warned that introduction into the body of any radioactivity above normal levels could theoretically initiate malignancies of various kinds which might take decades to become manifest in observable pathology (Martland 1931).

Robley D. Evans was the man who became the world's leading authority on the health effects of radium. In 1933, reviewing what was then known about the case of the radium dial painters, he estimated that the average dial painter ingested approximately six grams of paint per week, containing approximately 150 micrograms of radium. Although most of the radium was excreted, he estimated that 2% was retained within the body in target organs. He noted that as little as two micrograms deposited in bone had been shown to be a fatal dose. In 1934, Evans joined the physics faculty of MIT. Building on the work of Dr. Martland, he developed a quantitatively more accurate method of measuring the body burden of radium in a living subject which became the forerunner of modern whole-body counting. By 1941, Evans had accurately measured radium levels in twenty-seven dial painters. Seven of these women, with a body burden less that 0.5 microcuries, were in apparent good health. Twenty others, with a body burden of more than 1.2 microcuries each, manifested some degree of illness. In 1941, on the basis of these findings, the National Bureau of Standards and the US Advisory Committee on X-Ray and Radium Protection adopted 0.1 microcuries as the 'tolerance level' for residual radium in the body. This first safety standard for internal contamination of a radioactive substance was in place just in time to provide guidelines for a renewed and burgeoning radium dial painting industry that arose in the preparation of military equipment for the Second World War. As fate would have it, this guideline for internal emitters was in place just in time to provide a basis of safety for the Manhattan Project which got under way in earnest the year after.

Chronologically, it was radon and its decay products lingering in mines that were the first radionuclides to produce an adverse effect on human health. However, their radiological impact was not understood until much had already been learned from the study of radium. From the beginning of the fifteenth century, mines in the Erz mountains of central Europe were mined for a variety of minerals. Pitchblende mines located in the Schneeberg district of Saxony, Germany and in Joachimsthal in the Sudetenland, now part of the Czech Republic , had gained a reputation for causing high incidences of a mysterious disease called Bergkrankheit, "mountain sickness". Although local superstition attributed the cause to evil spirits, early physicians believed the cause to be somehow related to the ores being mined. An accurate diagnosis of the malady eluded physicians until 1879 when two German researchers provided evidence that the majority of deaths among Schneeberg miners were from malignant lung tumors. Many potential causative agents were identified as the possible source of this epidemic of lung cancers but in-depth investigation discounted each one. In 1921, the suggestion was first put forth that the cause might be radium and radium emanations, i.e., radon and its decay products. Animal studies conducted in Russia as early as 1904 provided some experimental confirmation of the hypothesis that radon was the causative agent. Proof of causation, however, was confounded as it became clear that two disease processes, silicosis and lung carcinoma, were coexistent in

many of the miners. Throughout the 1920s and 1930s, numerous studies were undertaken comparing air samples from various mines and the health of the populations of miners working those mines. In time, a clear correlation emerged between the level of exposure to radon and the frequency of lung cancer. Accurate investigation also confirmed the alarming situation that was taking place within the mines. By the mid-1930s, 50 % of miners in Czechoslovakia and 75-80% of miners from Schneeberg were dying of lung cancer.

In 1941, the US Advisory Committee on X-ray and Radium Protection adopted the first standard for a safe working concentration of a radioactive gas in air. This was based on air-sampling research on thoron conducted by Evans and associates at a factory making thorium gas mantles and a comparison of these findings with both animal studies and the published levels of radon measured in those mines in Europe that were known for high incidences of lung cancer. It was known that miners working in an atmosphere of approximately 10^{-9} curies of radon per liter of air faced an elevated risk of contracting lung cancer when compared to the general population. For matters of safety this level was divided by one hundred. Thus, a safe working atmosphere was first defined as 10^{-11} curies of radon or thoron per liter of air.

External Irradiation vs. Internal Contamination

Having outlined the historical development of the first radiation standards for x-rays applied to the outside of the body by x-ray machines, and for radiation released in the interior of the body by ingested radium and inhaled radon, it is appropriate to pause and reflect on the similarities and differences between external and internal radiation. A rudimentary knowledge of these phenomena are essential for understanding what happened to the development of radiation safety standards during and after the Manhattan Project.

Many people have difficulty understanding and visualizing the nature of electromagnetic energy. But all of us experience the effects of some of the frequencies within the full range of the electromagnetic spectrum, and from this everyday experience, we can develop an intuitive understanding of how x-rays and gamma rays interact with matter. We are all aware of the fact that every inch of the surface of our planet is bathed in man-made radio waves which we cannot sense but which we can tap into with the aid of a radio. With the push of a button, we can generate microwaves that can heat our food by increasing the vibration of the water molecules within it. Infrared energy from the sun makes molecules in our skin vibrate which we perceive as heat. Our experience of the myriad colors of the world is a result of visible light stimulating the light-sensitive receptors in our eyes. The

painful sunburn we receive at the beach results from the physiological response to ultraviolet light altering molecular structures in our skin cells. X-rays are even more penetrating than ultraviolet light. They can pass to different depths within our body or pass right through us entirely. They readily pass through soft tissue, but dense tissue, such as bone, is more likely to absorb them. Due to this contrast in the penetrability of soft and dense tissues, x-ray images of our teeth or bones can be created. More energetic than x-rays are gamma rays. Gamma rays are emitted from the nuclei of the majority of radioisotopes as they undergo radioactive decay and from the fissioning of nuclei in a nuclear reactor or a nuclear weapon detonation.

Electromagnetic energy exhibits characteristics of both waves and particles. When viewed as a wave phenomenon, what differentiates the various manifestations of electromagnetic energy are their wavelength, their frequency, and their energy. The transition along the spectrum from radio waves to gamma rays is marked by a transition to ever shorter wavelengths. Frequency, the number of waves passing a given point per unit time, increases as wavelength decreases. The shorter the wavelength, the more energy the wave transmits.

When viewed as a particle phenomenon, all forms of electromagnetic energy propagate through space as a stream of massless particles, called photons, traveling at the speed of light. These photons are quanta of energy in transit. The least energetic photons correspond to the waves with the longest wavelengths and the most energetic correspond to the waves of shortest wavelengths. Ultraviolet light is the threshold of penetrating radiation. The depth that it penetrates into the body is less than 1 millimeter, usually being completely absorbed by the epidermis of our skin. It is energetic enough to produce photochemical reactions in the superficial skin cells that lead ultimately to what we experience as sunburn. UV damage to melanocytes, the skin cells that produce the pigment melanin, can initiate a skin cancer. X- and gamma ray frequencies are more penetrating and more energetic than ultraviolet light, energetic enough to cause ionization of the atoms that constitute our physical structures.

It is crucial to emphasize that when x-rays and gamma rays interact with matter, the sole effect produced by the interaction is the transfer of their energy to orbital electrons of atoms in the material that absorbs them. These electrons gain energy, become excited, and their velocity increases. If sufficient energy is imparted to an electron, it will either jump to an orbit further from the nucleus or be ejected from the atom altogether. The removal of an electron from an electrically neutral atom creates a pair of oppositely charged particles — the negative electron and the positively charged atom — now possessing more positively charged protons in its nucleus than negatively charged orbital electrons. This is an

example of "ionization" and why x-rays, gamma rays, and high energy subatomic particles are referred to as "ionizing radiation". When ionizing radiation ejects electrons from molecules, ion pairs of positively and negatively charged atoms are formed. These charged particles are highly reactive and proceed to induce further disruptive chemical interactions in the medium in which they reside. By being able to break the bonds that hold molecules together, ionizing radiation leaves biologically significant molecules in shambles. Ionizing radiation creates chemical chaos in ordered biological systems. Such chemical disruption can lead to altered cellular function which in turn can ultimately manifest as pathology.

The energy of x-rays, gamma rays and particles ejected from the nucleus of radioactive atoms is measured in units called electron-volts (eV). A simple explanation of this unit of measure follows:

> An electron acquires energy in a high-vacuum tube in proportion to the voltage through which it falls, finally acquiring, at the moment of impact with the positive pole, a total (kinetic) energy that can be described by the multiplication of its charge by the voltage. Thus, if a single electron (carrying one unit of charge) falls through a difference in electrical potential of 10 volts, we say it has acquired a kinetic energy of 10 electron-volts. The electron-volt is abbreviated eV. Since an eV is a unit of energy, it can be converted to any other form of energy unit, such as the calorie, the BTU, the erg, or the joule, if we wish to do so (Gofman 1983).

Each x-ray or gamma ray photon, each alpha or beta particle can transmit energies equivalent to thousands or millions of electron-volts. In comparison, the energy required to break a single chemical bond between two atoms is between five and seven electron volts, although on average 33.7 electron-volts are expended in each severing of a chemical bond. This information is sufficient to explain the havoc introduced into an ordered system by ionizing radiation. For example, a single photon possessing the energy of 1 million electron volts has the capacity of breaking apart approximately 30,000 chemical bonds. The products of these ionizing events can in turn be responsible for creating further ionizations in a cascading effect, promoting further chemical chaos in the medium being disturbed.

In his book *Radiation and Human Health*, John Gofman provides a vivid description of the process of ionization:

> A compound containing excited electrons is said to be in an unstable,

> higher energy state, in which a variety of chemical reactions, otherwise not possible, become possible. Compounds that have lost an electron by ionization and are in a very unstable state can rearrange themselves into new compounds, or can react vigorously with other compounds. Compared to the orderly, precise ways by which low quantities of energy are ordinarily transferred from atom to atom, molecule to molecule, in the exquisitely functioning biological tissue, the introduction of an electron with 100 keV (100,000 eV) can only be described as chemical and biological mayhem — a veritable bull in a china shop.
>
> What about the electrons that have been ripped out of atoms or molecules by the first very-high-speed electrons? They can themselves rip electrons out of atoms of additional compounds, although these secondary electrons do not have nearly as much energy as the original 100-keV electron. So there is a cascading effect: an X-ray sets an electron into high-speed motion; that electron rips other electrons out of atoms and molecules, excites other electrons; the secondary electrons, ripped out, go on to rip still further electrons out of atoms and molecules, until finally all the 100 keV has been expended. All kinds of chemical reactions and rearrangements of atoms in molecules have occurred as a result of the excitation and ionization.
>
> To summarize, with ionizing radiation, electrons are removed from their atoms and endowed with energies huge compared to those of ordinary chemical reactions. Such electrons maraud for great distances (compared with atomic dimensions in angstroms) and have the chemical capability to break any kind of bond one might care to visualize. In biochemical systems, reactions are carefully controlled, often by special geometric juxtaposition of the reactants. A marauding high-speed electron simply does not notice all this elegant juxtaposition — it can break anything, anywhere. And once it has ripped an electron out of an atom in a molecule, that molecule is itself at such a high-energy level that it can produce all kinds of chemical reactions that would never have been possible without the ionizing radiation.

To understand how ionization is induced in biological systems by x-rays and gamma rays, it is helpful to construct an image of how this energy is delivered to the body and how it is absorbed. The following example, based on our everyday experience with visible light, is instructive. Let's imagine a human being standing in the middle of a darkened room, facing a light bulb mounted on the wall at one end. Outside the room, someone switches on the light and then immediately switches it off again. What transpires? At the moment of

illumination, a barrage of photons, massless packets of energy, floods the room. These photons travel outward from their source in straight lines in every direction until they interact with the electrons of the atoms making up the room's surfaces and any objects within. In some of these interactions, the photons are completely absorbed by the electrons. In these instances, the electrons gain energy from the photons and their vibration is subtly altered. This alteration to the electron is in turn transferred to the nucleus of the atom which causes the velocity of the entire atom to increase. This increase in velocity causes the atom to collide with neighboring atoms, thereby giving off the energy acquired from the absorbed photon as heat. The fate of those photons not initially absorbed is somewhat different. They reflect or scatter off the electrons they encounter and are sent coursing off in a different direction until they make another encounter where they are either absorbed or reflected/scattered yet again. Included within this tender maelstrom of photons dancing around the room are some that reflect and scatter off every surface and then manage to successfully converge on the light receptors of the eyes of the observer in the room which thereby makes miraculously perceptible every minute detail of every millimeter of floor and walls and ceiling. Being non-penetrating and non-ionizing, this tempest of photons saturating the room lacks the energy to pass beyond the atoms of the clothes of the observer or the surface layer of his skin to have any impact on the molecular makeup of his body.

Let us now alter the scenario.[5] Let us remove the light bulb and replace it with a unit that generates x-rays. Equally satisfactorily, we could replace the bulb with a shielded mass of some gamma-emitting radioisotope, cobalt-60 for example, a radiation source commonly employed in irradiation facilities where food is irradiated to kill microorganisms to delay spoilage or where such things as surgical equipment are sterilized. As before, the x-ray unit is switched on and then off, or in the case of the gamma emitter, the shield covering the gamma source is retracted and then immediately replaced.[6] The same phenomenon that occurred with visible light occurs once again: *a deluge of x-ray or gamma ray photons floods the room and bombards the observer*. (This time the event remains invisible to the observer due to the lack of sensitivity of his or her eyes to these more highly energetic photons.) Within this field of marauding photons, the ones reaching the body of the observer have a

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[5] For purposes of illustration, the myriad of variables that would enter a more technical presentation of this example are being intentionally ignored. These include, but are not limited to, the variable energies of the emitted x-ray photons, the distance of the subject from the source, the absorption of the photons by the air in the room, the attenuation of the beam, spreading out with distance, and variable absorption by different tissues.

[6] For purposes of accuracy it should be mentioned that photons emitted from x-ray machines do not all transmit the same energy. Their energies are variable over a range of energies. In contrast, all gamma rays emitted from one species of radioisotope will transmit a characteristic energy or a set of characteristic energies emitted in a fixed proportion unique to that particular radioisotope.

variable fate. Being so energetic, some pass right through his body without interacting with any of the atoms that make up his physical structure and constitute his life. These photons create no biological effect whatsoever. Other photons are reflected off the surface atoms of his body. These, too, can be discounted as having any biological impact. But in between these extremes, a hail of photons does successfully penetrate into every nook and cranny of his body. When photons, let us say all of one specific energy, penetrate into the body, there is no definite range through which they travel before interacting with an atom making up the body. Interaction is statistical in nature with a fractional reduction in the number of incoming photons occurring with each thickness of absorbing material. The variables that govern the phenomenon are the upper energy limit of the incoming photons, the thickness of the material they penetrate, and the atomic composition of this material.

Of the photons interacting with the atoms of the body, some only pass a micrometer into the body before their energy is absorbed by orbital electrons. This may occur in either a single encounter where the photon is completely absorbed (*the photoelectric effect*), its total energy completely transferred to the electron of the interaction, or the energy is partially transferred in each of multiple encounters (*Compton scattering*) while the photon scatters from electron to electron, transferring its energy bit by bit through each encounter. The electrons sufficiently energized by the photons are ejected from the orbits of their atoms and proceed to initiate secondary ionizing events in the affected medium. Other photons penetrate millimeters before interacting with electrons and giving up their energy to them. Others penetrate centimeters. Others pass deeper. No single structure or single layer of tissue receives the whole dose. *The dose is distributed throughout the entire mass of the body*. This is the key image that must be kept in mind when visualizing external irradiation of the body by x-rays and gamma rays. *The salvo of photons that penetrates the body deposits its energy throughout the whole system*. The density of this deposition, the amount of energy deposited per unit volume, will depend on a number of factors, the most important of which are the duration of exposure, the energy of the incoming photons, the density of the tissue receiving the radiation, and the depth of the tissue within the body. This is an example of what is commonly referred to as *whole body irradiation* or *whole body exposure*. The enormous quantity of photons involved in an exposure of this kind and the variable depths in which they are absorbed results in the energy being non-uniformly distributed throughout the body's mass. Under such circumstances, it is convenient to conceptualize the event as a dose to the whole body. The total amount of energy deposited is compared to the total mass of the tissues receiving it. Mathematically, the total dose can be divided by the mass to derive a figure of how much energy, ***on average***, is deposited per unit of tissue, such as ergs per gram.

In this type of exposure, the geometry of the event in most cases precludes uniform distribution of the dose throughout the body. Numerous variables are at play during the

time of exposure that affects the final distribution of the deposited energy throughout the mass of the target. The output of the radiation source, the degree of focus of the beam, the distance to the target, and so forth, all have an effect on how much energy actually reaches the body. Then, the side of the body facing the radiation source will receive more energy than the side turned away due to the intervening body mass. The differences in density of the tissues will also affect energy distribution since the denser regions will absorb proportionally more energy and reduce the quantity of energy passing beyond them. Similarly, with increasing depth into the body, density increases, further reducing the possibility of uniform distribution. Due to these and other variables, the concept of a whole body dose does not always capture the nature of a particular exposure to electromagnetic energy. In these instances, it may be more appropriate to speak of *partial body exposure*. For example, in some kinds of accidents the victim's hands or feet receive a disproportionately high fraction of the dosage depending on the position of the body in relation to the radiation source. In these instances, it makes sense to talk about receiving a dose of so many sieverts to the hands or so many millisieverts to the feet. In other exposure events, an *organ dose* may be medically significant. This represents the quantity of energy deposited in the mass of an organ, or multiple organs, once again dependent on the geometry of the event.

To drive the point home still further, in all instances of external exposure to electromagnetic radiation, the same fundamental model for calculating dosage is applied. The quantity of energy absorbed is averaged over the mass of the tissue(s) into which it is deposited. Decades of experience with those exposed to external radiation has enabled correlations to be established between different dosages deposited throughout the whole body or some portion of the body and the likely physiological responses that will occur. Acute radiation syndrome has been studied extensively, allowing medical practitioners to anticipate the types of injury induced by different quantities of deposited energy, the body's response to this injury, and to predict with a high degree of reliability the likely prognosis for the individual receiving exposure.

Radioisotopes undergoing radioactive decay within the body is a *qualitatively* different phenomenon from external exposure to photons of electromagnetic radiation. To glean an understanding of the difference, let us first imagine that a mircometer-sized particle of an alpha emitting radionuclide becomes lodged in the lung. Depending on the exact dimensions of the particle, it may be composed of billions or trillions of atoms. While residing in lung tissue, the atoms will undergo radioactive decay at a rate determined by a physical characteristic unique to that particular radioisotope called its *half-life*. The half-life is the time required for one half the atoms in a sample to spontaneously undergo radioactive decay by emitting particles and/or energy from their nuclei. When a radioisotope decays by emitting an alpha particle, each alpha particle will transmit the same discrete

energy, the unique signature of that particular radioisotope. Sometimes, the emitted alpha particles will transmit a couple of different unique energies in fixed proportions. These are known quantities and can easily be looked up in tables listing the characteristics of the different radioisotopes. In fact, the energy transmitted by an alpha particle is a characteristic feature of each alpha emitting radioisotope and can be used to identify the radioisotope from which it is emitted. A single alpha particle ejected from the nucleus of a radioactive atom can transmit an energy of millions of electron-volts. For instance, an alpha particle emitted from an atom of plutonium-239 possesses an energy of 5.1 million electron volts (MeV) and an atom of uranium-238 emits alpha particles of 4.2 MeV. Thus, the energy of a single alpha particle transmits the energy sufficient to break hundreds of thousands of chemical bonds and liberate hundreds of thousands of secondary electrons that will go on to initiate further ionization.

When an alpha particle is emitted from a radioactive atom in the particle entrapped in the lung, it does not travel very far. Although the distance capable of being traversed in tissue is dependent on its initial energy, on average an alpha particle has a range of between only 30 and 40 microns. This is equivalent to three or four cell diameters. The most energetic alpha particle from radioactive decay traverses no more than 100 microns. So, if a particle made up of an alpha-emitting radioisotope is trapped in tissue, one can visualize it at the center of a sphere possessing a radius equivalent to the maximum distance capable of being crossed by the alpha particles. All alpha particles emitted by the entrapped radioisotopes will deposit their entire energy within this tiny volume. Thus, in a very localized microscopic region, a massive amount of ionization is introduced, severely disrupting the chemical integrity of the cell(s) through which the alpha particle passes. For this reason, alpha particles are classified as *densely ionizing*. In contrast, the ionizing events promoted by rapidly moving, energetic electrons liberated from their atoms by photons are separated by much greater distances. Photons are thus considered as *sparsely ionizing*.

As with x-rays and gamma rays, alpha particles lose energy by interacting and transferring that energy to the orbital electrons of the atoms in their immediate proximity. The reason alpha particles travel such a short distance is because they are so effective in initiating ionization. They rapidly decelerate in the process of transferring their energy to nearby electrons. Within that 30 to 40 micron range, they create a dense pattern of ionization. Alpha particles contain two protons and thus possess two units of positive electrical charge. The orbital electrons spinning around the nuclei of atoms possess one unit of negative electrical charge. Under these circumstances, one can visualize an alpha particle as a powerful magnet. Once hurtled from the nucleus of an atom undergoing radioactive decay, the alpha particle tugs on the electrons of the atoms it passes, exciting them or actually causing ionization by dislodging these electrons from their atoms altogether. So overwhelming is the

electromagnetic field of the alpha particle, that it causes massive numbers of ionizing events along its path. With each ionization, the alpha particle loses energy to the electrons as these reciprocate by putting a drag on the alpha particle. As the alpha particle slows, the density of the ionizations it creates increases. So effective is this exchange of energy that the alpha particle comes to a complete stop quite rapidly, picks up two stray electrons, and stabilizes as an atom of helium.

To fully understand the phenomenon of internal contamination by radioisotopes, one must also understand the kinetics of a beta particle. A beta particle is the same thing as an electron, but it is energetically emitted from the nucleus of some species of radioisotopes at the moment of radioactive decay. Its mass is 1/7300 that of an alpha particle. Due to energy instabilities within the nucleus of certain species of radioactive atoms, a neutron transforms into a proton and is accompanied by the emission from the nucleus of a beta particle and a neutrino. Due to the nature of the neutrino (no mass and no electrical charge), it does not interact with the atoms of the body and so is not an issue in radiation protection. It does, however, carry off energy from the nuclear transformation. As a result, beta particles from a particular radioisotope do not possess the same energy as the characteristic emissions of alpha particles. Beta particles for each radioisotope can transmit a maximum energy for that radioisotope and any energy less than that down to zero. For all practical purposes, the average energy of beta particles emitted from a radioisotope can be considered to be one third of the maximum energy for that radioisotope. The maximum energy of the most energetic beta particles can be hundreds of thousands of electron-volts. Once emitted from the nucleus, a beta particle behaves as any electron liberated from its atom by x-rays, gamma rays or alpha particles. By electrostatic interaction, its one unit of negative electric charge will repel orbital electrons of the atoms by which it passes with sufficient energy to ionize them, liberating these electrons that will induce further ionization in surrounding atoms. Beta particles travel much farther in tissue than alpha particles. The variable energies of beta particles result in a variable range of distances traversed through tissue. While in transit, they transfer less energy per micron traveled, thus the pattern of ionization created by beta particles is less dense than that of alpha particles. Consequently, it is less likely that beta particles will create as much local havoc in individual cells or individual cell structures as alpha particles. Beta particles can travel millimeters in tissue equivalent to a distance of approximately 100 cell diameters.

Early Research into Internal Exposure from Radionuclides

Before recounting the dramatic advancement in radiation safety ignited by the

Manhattan Project, a few more relevant details need to be introduced. As the discovery of new, naturally occurring radionuclides proceeded during the first three decades of the twentieth century, novel applications were developed for their utilization. An idea that revolutionized the fields of physiology and biochemistry was proposed by Georg Karl von Hevesy in 1911. He theorized that by introducing radioactive tracers — chemicals tagged with radioactive atoms — into an organism, their migration could be monitored for the purpose of mapping basic metabolic pathways. The first practical application of this technique did not occur until 1924 when von Hevesy, J.A. Christiansen and Sven Lomholt used lead-210 and bismuth-210 to perform the first radiotracer studies in animals. Humans were first injected with radiotracers at Harvard in the late 1920s by Herman L. Blumgart to study the velocity of the circulation. These early radiotracer studies were limited in scope, however, due to the small number of known naturally occurring radioisotopes that also evidenced some metabolic significance. The two discoveries that catapulted this methodology to a central place in biomedical research was the discovery of artificial radioactivity by Irene Curie and Jean Frederic Joliot in 1934, and the development of the cyclotron by Ernest O. Lawrence in the first years of the 1930s. Within a month after the announcement that man could create radioisotopes artificially, the cyclotron at Berkeley was bombarding a variety of chemical targets with high energy particles and churning out on demand a slew of different artificial radioisotopes. Physiologically important elements were made radioactive and then made available for tracer studies in animals and humans. In 1937, Joseph Hamilton was the first to use artificial radioisotopes to study the human circulatory system. Administrating radioactive sodium orally to test subjects, he measured absorption time of the radioisotope into the bloodstream, and then by means of a geiger counter held externally to the body's surface, he charted the pathways and distribution of the sodium as it traversed the body. In other studies, test subjects held geiger counter probes in their hands and comparisons were made of the varying times required for the ingested radioisotopes to be absorbed and pass via the circulation into the hands. Other studies compared the rates of excretion of various radioisotopes in healthy and sick individuals. This procedure allowed for the establishment of biochemical parameters for normal functioning and the recognition of markers that would signal the onset of pathology. Hamilton was the first to recognize the need for a biologically significant radioisotope of short half-life that would not create harmful side effects in test subjects. In response, Glenn Seaborg and Jack Livingood bombarded the element tellurium with deuterons in the Berkeley cyclotron and created iodine-131 which possessed a half-life of eight days. This isotope was then used to study the uptake of iodine by the thyroid gland. In 1938, Emilio Segre discovered technetium-99m which in time became the most widely used radioisotope in diagnostic studies. The trend, started at Berkeley, spread outward. As years passed, cyclotrons were built at a number of universities, novel radioisotopes were discovered, and new applications evolved.

A number of researchers saw greater promise for the use of radioisotopes in medicine than simple tracer studies. Their dream was to develop magic bullets out of radioisotopes that, once introduced into the body, would find their way to malignant cells and destroy them. In pursuit of this goal, John Lawrence conducted experimental treatments on mice suffering from leukemia. By administering phosphorus-32 to the animals, a radioisotope known to concentrate in bone tissue, he hoped that upon radioactive decay the bone marrow would be bombarded with energetic beta particles. Human trials were first performed by Robert Stone and Joseph Hamilton. Working out of the medical center at the University of California in San Francisco, they injected radioactive sodium into two leukemia patients in 1936. The following year, on December 24, John Lawrence injected phosphorus-32 into a leukemia patient at the University of California at Berkeley. In 1940, hyperthyroidism was first diagnosed and treated using iodine-131. Also in 1940, polycythemia vera, a rare disease characterized by an overabundance of red blood cells, became the first disease to be successfully controlled with doses of radiopharmaceuticals. During this same year, iodine-131 began being used both to diagnose and treat hyperthyroidism.

The early years of exploration into the use of radioisotopes in tracer studies and as a possible treatment modality spurred the development of new technologies and procedures. New instrumentation evolved. New methodologies were developed to ensure the safe preparation and handling of radioisotopes. Methods for quantifying and calculating safe dosages for each radioisotope were explored. As more people began working with radioactive substances, measures for protecting and limiting worker exposure had to be designed. Investigation was demanded into the radiation toxicology of beta and beta-gamma emitters. Synthesis of a wide variety of compounds containing radioisotopes took place, and their behavior within the body was explored. The kinetics of individual radioisotopes introduced into the body were mapped and comparisons were made between the uptake of a radioisotope by the organ of interest relative to its distribution in other tissues or in the body as a whole. With the accumulation of knowledge, baselines were established to delineate the behavior of radioactive elements and compounds in healthy and diseased states.

Radiation Safety During the Manhattan Project

From the discovery of radioactivity in 1898 to the advent of the Second World War, human activity in isolating and concentrating naturally occurring radionuclides or creating and concentrating artificially produced radioisotopes was on such a small scale that its impact to human health and well-being was, for the most part, insignificant. Only isolated populations of people received significant internal exposure: uranium miners, patients receiving at first radium and later artificially produced radioisotopes for medical treatment,

the radium dial painters, chemists synthesizing products containing radioactive substances, those touched by the radium craze, and so forth. The amount of radioactive material in the hands of mankind was small, limited to a few radionuclides, and found only in specialized locales. During this period, primarily through the exploration of the possible uses of radium, the hazards of internal exposure to radioactivity were identified. Through animal studies, rigorous scientific investigation, and a prolonged process of trial and error, accompanied at times by profound human suffering, researchers and medical specialists achieved a milestone by determining first safety standards for internal exposure to radium and inhaled radioactive gases. The new realities just over the horizon, however, would relegate this hard-won knowledge to the shadows as massive quantities of radionuclides were produced and dispersed in abundance over the earth.

The Manhattan Project and the diverse nuclear enterprises that it spawned radically altered forever the quantity and composition of radionuclides found on the surface of our planet. Simultaneously, new pathways were created for radioactive material to gain access to the interior of human bodies. In the process of building bombs and fabricating the fuel for commercial nuclear reactors, hundreds of millions of tons of ore, impregnated with diffuse amounts of radionuclides, were unearthed. This radioactive material was in turn extracted and combined in unnatural concentrations. Fed into nuclear reactors, the dream of the alchemists was at last fulfilled. A plethora of radioactive isotopes that had never before existed on the face of the earth was brought into creation and introduced into the biological realm. The detonation of nuclear weapons, the planned and accidental releases from nuclear power plants, and the makeshift efforts at disposal of radioactive waste then scattered this material, like seeds to the wind, throughout the environment creating a radioactive burden for the earth that had never before existed. Organisms, while carrying out basic life processes, inevitably internalized atoms of this material. Through food chains, radioactivity was passed along from organism to organism in ever greater concentrations with the interior of human bodies often being the final repository of biologically significant quantities of radioactivity.

With the Manhattan Project, the quantity of radioactivity present in the human domain exploded astronomically. From 1898 until World War Two, the total radioactivity of the radium that had been extracted from ores worldwide and utilized by doctors, scientists, and manufacturers amounted to approximately 1,000 curies (the radioactivity of one kilogram of radium). In comparison, 1,000,000,000 curies of radioactivity were dispersed over the pristine tropical paradise of the Bikini Atoll in 1946 after the detonation of Shot Baker, the second of two atomic weapon tests conducted as part of Operation Crossroads.

At the start of the Manhattan Project, virtually nothing was known of the hazards

to health posed by plutonium, enriched uranium, and the over two hundred isotopes of thirty-four elements created by the fissioning of uranium. To protect the tens of thousands of workers who potentially would be at risk while undertaking to build the bomb, medical research was one of the first priorities. On October 15, 1942, research on the metabolism of the fission products of uranium got underway at the University of California. This predated the first successful chain reaction in the atomic pile in Chicago and was made possible by the Berkeley cyclotrons firing deuterons at a uranium target and creating the radioisotopes that later would be created in mass in nuclear reactors. The derived radioisotopes were then used in tracer studies on rats to determine such things as the percentage of absorption from oral administration, the percent of accumulation in the principal organs of retention, and rates of elimination. Preliminary findings on fourteen biomedically important radioisotopes were available within a year. Major medical research also got underway at the University of Chicago. Studies on the acute toxicity of different fission-produced radioisotopes were followed by studies of their carcinogenic potential. Animal studies were also undertaken to study the transfer of radioisotopes from mother to developing fetuses in mice and rats, and to gauge their impact on embryonic development.

Besides fission products, Manhattan Project scientists were in urgent need of information on the physiological effects of plutonium, of which virtually nothing was known. Plutonium-239 was first isolated at Berkeley in 1941. Upon discovery that plutonium could be induced to fission, efforts got underway to accumulate appreciable quantities of the new radioisotope. Up to the fall of 1943, only 2 mg (milligrams) of plutonium were in existence. So precious was this small quantity that none could be spared for biomedical studies. As production reactors came on line and the quantity of plutonium increased, biomedical studies were initiated to evaluate the radioisotope's effect once introduced into an organism. In January 1944, 10 mg of plutonium, which was one tenth of all the plutonium then in existence, was allocated for animal studies at Berkeley and Chicago to determine its toxicity. Initially, plutonium was thought to be less toxic than radium based on their comparative half-lives. Radium-226, with a half-life of 1,600 years, was calculated to be fifteen times more toxic than plutonium-239, with a half-life of 24,500 years. This, however, failed to take into account the amount of energy deposited in tissue as a result of radioactive decay. The average energy of an alpha particle emitted from plutonium was 5.15 MeV. The energy deposited in tissue from the decay of a radium atom plus its decay products totaled approximately 14.4 MeV. By first appearances, radium was more toxic than plutonium, and a safe body burden was set at 5 micrograms (mcg), fifty times that of the safe body burden for radium. But further research disproved this hypothesis. Both radium and plutonium are alpha emitters and bone seekers. Plutonium, however, was found to accumulate on bone surfaces closer to the blood-forming marrow while radium tended to accumulate throughout the bone volume in mineralized bone. Though less readily absorbed than radi-

um, plutonium once absorbed is retained longer and excreted more slowly, thus depositing more energy in more sensitive tissue. Together, these facts helped to determine that plutonium is in fact thirty times more toxic than radium. The limit for internal contamination with plutonium was reduced in 1945 to 1 mcg. At Los Alamos, plutonium was considered so toxic that a policy was established for immediate amputation above the point of entry if a worker absorbed any quantity of the element in a cut or scratch to the hand.

Within the secretive atmosphere of the Manhattan Project, radiation was referred to as the "special hazard". The Health Division had responsibility for radiation safety. It in turn was subdivided into three sections. The health physics section was responsible for detecting radiation and establishing safeguards. The medical section was responsible for monitoring workers. And the biological research section undertook research into the potential health effects of the materials that workers came in contact with. Workers most at risk in areas of high levels of irradiation carried dosimeters and film badges to measure exposure to x-rays and gamma rays. One conundrum that persisted throughout the Project was the lack of accurate information on what would be a permissible dose for internal contaminants. The 0.1 microcurie guideline for radium was the only established guideline that the Health Division had at its disposal. Because of the plentitude of unknowns concerning internal exposure to the new radioactive substances, radiation safety for workers during the Manhattan Project was predicated on avoiding intake altogether. Occupational procedures throughout the project were designed around this guiding principle.

During the Manhattan Project, thinking on radiation safety was based on the concept of the "permissible dose." The amount of radiation exposure permitted was a compromise between what was judged to be safe at the time and the dictates of practical utility and engineering feasibility. In an attempt to assess radiation exposure, blood and urine samples were gathered from those workers coming in contact with material presenting a radiological hazard. Initially, it was believed that observable changes in blood characteristics would serve as a gauge for radiation injury. The natural variation in normal blood counts between individuals, however, made this avenue of evaluating exposure unworkable. Without adequate devices to measure alpha radiation, there was no way to accurately determine the amount of plutonium absorbed by workers. At first, nose swipes were the only tool available to Manhattan Project medical personnel to test for the lung burden of plutonium. By the end of 1944, a method was developed for detecting trace levels of plutonium in excreta wherein as little as 1 picocurie[7] of plutonium could be detected in urine samples.

[7] A picocurie is one-trillionth of a curie. It represents 0.037 disintegrations per second. This is approximately 2 disintegrations per minute.

At this point, a brief digression will prove of interest. While at MIT in 1936, Robley Evans was approached by a representative of the Food and Drug Administration who petitioned him to conduct research to establish safe levels for radium in commercial products that would ensure no harm to consumers. Toward this end, Evans undertook a four-year study on rats, feeding them radium and studying the physiological impact. Over time, the rats manifested the same pathologies suffered by the radium dial painters which included spontaneous bone fractures, bone tumors, and bone cancers. But a seemingly insoluble obstacle arose. To recreate these pathologies in rats required that they be fed several hundred times the amount of radium that had been ingested by the dial painters. From this experience, Evans recognized the limited usefulness of animal studies when attempting to assess the effects of radiation in man due to the differences in radiosensitivity across species. Discontinuing his animal studies, Evans quipped, paraphrasing the English poet Alexander Pope, "the proper subject for the study of man is man".

This same conclusion was reached by Manhattan Project medical personnel. One urgent problem was finding a method to accurately determine the body burden of internally deposited plutonium in a contaminated individual from the amount of plutonium he excreted. Animal studies provided inconclusive results. Different animals excreted plutonium at different rates. On March 23, 1945, Robert Oppenheimer, director of the Manhattan Project at Los Alamos, authorized that experiments be conducted on humans to identify the ratio between excreted and retained plutonium. In response to this directive, eighteen patients were injected with plutonium between 1945 and 1947: one at Oak Ridge Hospital, eleven at Strong Memorial Hospital at the University of Rochester, three at the Billings Hospital at the University of Chicago, and three at the University Hospital in San Francisco. After the patients received the injections, their excreta were collected and sent to Los Alamos for analysis. One of the Rochester patients died six days after injection, supposedly from pneumonia and other preexisting ailments. His organs and other autopsy material were harvested and shipped to Los Alamos for analysis. Two of the Chicago patients also died, again from supposedly pre-existing conditions, after receiving injections of 94.91 mcg of plutonium. (Recall that the Manhattan Project limit for internalized plutonium was 1 mcg.) The patients selected for these studies were chosen because they were judged to have limited life expectancy. Thus, their added plutonium burden would not lead to long-term complications. Only one of the eighteen signed a release form. None had knowledge that they were being injected with radioactive material. None had knowledge of being the subject of an experiment. None had knowledge that there was no therapeutic benefit to the injections they received. Although an obvious violation of human rights, the nuclear community profited from the tainted science. Results of this study, Los Alamos report LA 1151, was published in September 1950 under the title "Distribution and Excretion of Plutonium Administered Intravenously to Man". The article described the

experiment, the metabolism of plutonium in the human body, and provided a formula for calculating the body burden for plutonium from urinalysis.

These first human radiation experiments with plutonium set a precedent for a number of secret experiments conducted on human subjects that continued until 1974. During that period, some 430 radiation experiments were performed on approximately 16,000 subjects, for the most part without informed consent. The secrecy surrounding these experiments was paramount and had the full backing of the US government. This came to light when an openly self-incriminating 1947 memorandum surfaced from the US Atomic Energy Commission, signed by O.G. Hayward:

> It is desired that no document be released which refers to experiments with humans and might have adverse effects on public opinion or result in legal suits. Documents covering such work field should be classified "secret" (Schott *et al.*).

For those consumed by the goal of weapon development, the unethical exploitation of sick, poor, ignorant, disadvantaged human beings was a logical, acceptable, and indispensable method of advancing the nation's nuclear program. When the veil of secrecy was lifted on this human rights tragedy by Secretary of Energy Hazel O'Leary on December 7, 1993, the news evoked outrage throughout the country that such experimentation on human guinea pigs, usually associated with regimes such as that of Nazi Germany, could have been condoned and conducted within the United States. What was left unsaid at the time of the revelation of these human experiments, and which still remains unacknowledged, is that these human experiments successfully yielded in abundance the data for which they were designed. Radioactivity in man was deeply probed using unsuspecting humans as guinea pigs. It was primarily as the result of these experiments that parameters were established for safe exposure of radioactivity in the areas of medicine, industry, space flight, and warfare.

It would be irresponsible to pass over the tragedy of the human radiation experiments without pause. These injustices will be remembered long into the future for they reveal the nature of the mentality that accompanies involvement with the development, governance, and deployment of weapons of mass destruction. Mentally healthy human beings don't wield horrific weapons. Inescapably, people who do involve themselves with weapons designed to exterminate large segments of humanity lose their own humanity in the process. (This idea is further developed in the later chapter *The Mentality of Genocide*.) To contemplate genocide and engage in deeds that foster its likelihood fundamentally disturbs the integrity of the psyche. The personality becomes fragmented. Two selves come

to occupy the same body, the self that lives in the world like everyone else and the self that coldly and methodically, without empathy and compassion for the lives of others, goes about making preparations for mass extermination. Disturbingly, this tendency can become institutionalized and shared among a group of people. The classic example of this tendency is the human radiation experiments of the nuclear warriors. While readying the nuclear inferno for faceless millions, physicists and physicians of the Manhattan Project lost their moral compass and freely endorsed studies that demanded that humans be reduced to guinea pigs and receive radiation exposure without their knowledge or consent. Although endorsing a policy of amputation for any employees taking up a speck of plutonium in a cut, they unhesitatingly endorsed injecting plutonium in innocent victims. To their minds, the furtherance of the genocidal endeavor was all important. Small injustices, such as the sacrifice of the welfare of a few innocent people, were deemed a suitable price to pay for the scientific knowledge it would yield. Weapons of mass destruction nurse this mentality among their devotees. And it is this mentality that is the true enemy of humanity. And yet, populations entrust their welfare and their future to the guardians of weapons of mass destruction, who are consumed by this mentality.

In returning to the historical narrative, the discussion now arrives at a fateful moment in the history of radiation safety. The Manhattan Project was a gigantic experiment in applied physics. Physicists dominated all aspects of the science required to build the bomb. This included all aspects of the Health Division. When the Manhattan Project got under way, the only standards available to the Health Division were those established prior to the war by, respectively, the US Advisory and the International Committees on X-ray and Radium Protection. The complicated undertaking of building the bomb and having thousands work in close proximity to high levels of radioactivity and novel radioisotopes demanded a revolution in all aspects of radiation safety. Herbert M. Parker, a British radiological physicist, headed the Protection Measurements Group of the health physics section of the Health Division. Besides being responsible for designing a new generation of radiation detection equipment, Parker had to overcome the major obstacle that had confounded researchers and radiologists over the previous two decades: how to devise a meaningful way of relating x-ray exposure to biological effect. The exposure to x-rays impinging on the surface of the body from an outside source was quantified by so many roentgens — a measure of the amount of ionization that quantity of x-ray energy would produce in air. Once that x-ray energy passed into the body, it was traveling through a different, nonuniform medium and interacting with a variety of biologically significant molecular structures. Some means were necessary for quantifying the changes being induced within the biological system. Ionization of the air external to the body, or the gas within a radiation detector, was one phenomenon. Biological changes in an organism due to that radiation was another phenomenon. The problem was how to connect these two into a meaningful

framework. A further problem also confronted Parker. The roentgen was a measurement for x-rays and gamma rays. People working in the Manhattan Project were potentially going to be exposed to additional radiation in such forms as alpha particles, beta particles, and neutrons. In order to effectively protect workers from the cumulative effects of different types of radiation, what was required was a method of quantifying the dosages from different types of radiation by a single unit of measurement. In this way, exposure to a combination of gamma rays and beta particles, for instance, could be combined in a meaningful way to denote the total dosage of radiation received.

Parker was a physicist. He brought a physicist's mindset to the problem of how radiation impacted on biological systems. And the simple and practical solution he devised was a physicist's solution. To Parker, when looked at abstractly, the essence of radiation's interaction with matter was the transfer of energy. X-rays transfer electromagnetic energy from an x-ray machine to the human body. These x-ray photons, interacting with the atoms of the body, transfer their energy to orbital electrons. Alpha particles and beta particles, with the kinetic energy they derive from being ejected from an atom undergoing radioactive decay, transfer energy from the nucleus of atoms to the electrons of the atoms within the human body with which they collide. What these types of ionizing radiation have in common is this capacity to transfer their energy into the body where it is absorbed by electrons, thus exciting them in their orbits and/or ejecting them from the atoms to which they are bound. As the amount of energy absorbed by the body is increased, so greater is the amount of ionization and biochemical disturbance to the system. Sufficient disruption results in altered function which is manifested in various forms and degrees of injury. *Thus, from this point of view, the extent of alteration to a biological system is directly related to the amount of energy absorbed*. To quantify this phenomenon, Parker devised a new unit of measurement for absorbed dose. The *rep* (roentgen equivalent physical) measures dosage as the amount of energy in ergs deposited per gram of material. Undergoing slight modification, the rep evolved into the *rad* (radiation absorbed dose) which represents the absorption of 100 ergs per gram of material. The rad is a convenient unit of measure. It is used to describe the amount of energy absorbed by any type of material (be it wood, metal, bone, muscle, or whatever) from any type of radiation.[8] To understand the impact that Parker's mentality

[8] The roentgen was retained as a unit of measurement for exposure. In health physics it represented the amount of ionization in air caused by a quantitiy of radiation as measured from outside the body. The rad was the unit of absorbed dose, measuring how much energy was absorbed by the material with which it interacted. Precise measurement determined that 1 roentgen corresponded to the absorption of 83 ergs per gram of air and the absorption of 93 ergs per gram of tissue at the body's surface. So close were the two units of measurement that they began to be used interchangeably. This also permited gas filled detectors, that measured ionization, to provide information about the absorbed dose at the surface of the body.

and mode of thinking had on the subsequent development of radiation safety, one point is essential to keep in mind: in Parker's conceptual model, the quantity of energy absorbed is treated as if it is uniformly distributed throughout the mass that absorbs it, i.e., the energy is "averaged" over the entire mass. This is what the rad represents, ergs per gram. To do this makes perfect sense within the mathematically oriented discipline of physics. However, as we shall see later in the discussion, this model is woefully inadequate when transferred into the discipline of biology where averaging energy over a mass of living cellular material is, in many instances, a useless concept for determining biological effect.

Parker was aware that the model he was developing had to account for the fact that different types of radiation (x-rays, alpha particles, beta particles, etc.) differed in how effectively they induce change in a biological medium. Consequently, Parker devised a second unit of measure that took these differences into account. First, for each type of radiation, experimentation was conducted to determine its Relative Biological Effectiveness (RBE) — the relative damage each caused to living tissue. The biological dose delivered by a quantity of radiation was then determined by multiplying the amount of energy absorbed (measured in reps or roentgen equivalents physical) by the RBE of the type of radiation that delivered the dose. The unit of measure of the product of these two quantities was the *rem* (roentgen equivalent man). As a hypothetical example, suppose the health effect to a type of tissue created by 1 rep delivered by alpha particles is compared to the health effect delivered by 1 rep of gamma rays, and it is found that the alpha particles produce ten times as much health effect. Alpha particles would be assigned an RBE of 10. What would be said is that the alpha particles deliver 10 rem to the body while the gamma rays deliver 1 rem. Both forms of radiation deliver the same amount of energy to the body. The biological impact of the alpha particles, however, is ten times as great.

The quantitative model that Parker developed introduced clarity into people's thinking about radiation's interaction with matter. So successful was this approach that it influenced all future thinking on the subject of radiation protection. According to this model, the biological effects of radiation were proportional to the amount of energy absorbed by the target, whether this was a particular organ or the body as a whole. To determine the amount of energy transferred, all types of ionizing radiation were now quantifiable using a single unit of measure, and the varying capacity for different types of radiation to produce biological alterations could be accounted for mathematically. Scientific investigation could now proceed to build a body of knowledge comparing the quantities of radiation absorbed to the biological effects they produced in different types of cells, tissues, organs, systems, and the whole body. Radiation protection was given a scientific footing that would allow it to keep pace with the revolution that was taking place in nuclear physics and in the new world

created by the Manhattan Project.

But a subtle flaw lay at the heart of Parker's model. It was all built upon the unfounded assumption that biological effects of radiation depended solely on the amount of energy absorbed. What made perfect sense from the point of view of the physicist was not in harmony with basic biological realities. At first, this wasn't apparent. Only in the latter part of the 1950s, after new fundamental discoveries were made in biology, did the major shortcomings to the model begin to intrude into what was already orthodoxy in radiation physics. Thus, the physics-based model — which was hugely successful in advancing radiation research — turned out in time to have been a conceptual blunder that blinded many to a true understanding of the biological effects of radiation. More significant is the fact that it continues to blind the understanding of people, even people who have spent years of study on the subject.

While recounting this history, we are simultaneously stalking the resolution to a mystery. Long after discoveries in biology highlighted the shortcomings of the physics based model of radiation's effects on living systems, it nevertheless continued to serve as the basis for formulating radiation protection standards. Although scientific understanding advanced, an antiquated and inaccurate model continued to be relied upon for determining the health effects of ionizing radiation on the human body.

The enigma that must be unraveled is WHY?

The answer lies in events that occurred soon after the end of the Second World War.

To conclude this section, a public relations campaign on behalf of the radioactive atom was forced into existence at the very beginning of the nuclear age. After the bombings of Hiroshima and Nagasaki, portions of the surviving Japanese population of these cities began manifesting symptoms of acute radiation syndrome. Newspapers and radio broadcasts around the world carried the message that people who had escaped the blast unscathed were nevertheless dying of some mysterious unidentified malady in the weeks following. Wilfred Burchett, the first civilian reporter to enter Hiroshima unescorted, wrote an article entitled "I Write This Warning to the World" which was published in London's *Daily Express* on September 5, 1945. The article stated:

> In Hiroshima, 30 days after the first atomic bomb, people are still dying, mysteriously and horribly — people who were uninjured in the cataclysm — from an unknown something which I can only describe as the atomic plague.

Such a report was in sharp contrast to press releases from the US government purporting that residual radioactivity in the cities was insignificant and delayed radioactive effects among the population would likewise be insignificant. General Leslie Groves, military director of the Manhattan Project, was forced to mount a public relations campaign to rescue American respectability and assuage the mounting worldwide concern over the lingering aftereffects of an atomic bomb detonation. An investigating team was hastily dispatched to Japan to prove that radioactivity was not a problem. After surveying the wreckage of Hiroshima, this team reported their findings at a news conference held in Tokyo on September 12. They announced that radioactivity presented no problem to the people of Hiroshima, and no further deaths would occur as a result of the blast. Any people still suffering were suffering from burns and traditional blast effects. Much later, the truth emerged. Medical investigators who spent time in Hiroshima estimated that between 15 and 20% of the deaths were due entirely to radiation. *Minimum* estimates suggested that 20,000 people died of radiation and that another 20,000 suffered from radiation injuries of various kinds.

Radiation Safety After the War

While the Second World War was being fought, the work of both the US Advisory Committee on X-Ray and Radium Protection and the ICRP lapsed into inactivity. During their absence from the scene, the nuclear sciences underwent a revolution. The meaning and implications of "radiation safety" before the war had little to do with the new realities in existence by war's end. In the 1930s, issues of radiation safety revolved around establishing exposure limits, primarily to patients and medical personnel. In the post-Manhattan Project world, radiation safety had to encompass the burgeoning nuclear industry as well as potential exposure to the entire population by radioactivity released into the environment. These new realities reinforced the implication, inherent in the concept of "permissible dose," that what was deemed an acceptable risk was a judgment call made by members of regulatory agencies, and that members of society had to accept an element of risk to their own health for nuclear technology to flourish. Defining exactly what constituted *acceptable* risks to the general populace, however, was never a topic of public debate. It was left in the hands of those few charged with developing radiation protection standards who, needless to say, were people directly involved in the development of weapons of mass destruction or who were intimately associated with such people. And it is in their hands that radiation safety has remained up until today.

With the quantum leap in the amount of radioactive material present in the human

domain after the war, new standards of safety were urgently needed, but a temporary void existed as to what organization would develop them. The Atomic Energy Commission came into being on August 1, 1946, and took charge of all the facilities and all of the nuclear materials of the Manhattan Project. Twenty days later, Lauriston Taylor revived the US Advisory Committee and began a vigorous campaign to have that organization recognized as *the* voice of authority on radiation protection in the United States. Taylor's advocacy succeeded. The first meeting of the Committee was convened with the intention of initiating revision of the National Bureau of Standards Handbook 20, *X-ray Protection*. At that meeting, the decision was made to adopt a new name, the National Committee on Radiation Protection (NCRP). (When the NCRP became a US Congressional Charter Organization in 1964, its name changed again to the National *Council* on Radiation Protection and Measurements.) The decision was also made that membership should be extended beyond those with an interest in the medical application of radiation to include representatives from all organizations that had a vested interest in furthering standards for radiation protection. When reformed, membership on the committee consisted of eight representatives from various medical societies, two from manufacturers of x-ray equipment, and nine from government agencies including the Army, Navy, Air Force, National Bureau of Standards, the Public Health Service, and the Atomic Energy Commission. As time passed, the NCRP evolved into an organization of tremendous influence. The recommendations it propounded, along with those of the ICRP, became the basis of federal, state, and local statutes for managing radiation hazards.

From the outset of their formation, a codependent relationship developed between the Atomic Energy Commission, the agency that managed the nation's nuclear program, and the NCRP, the organization which recommended standards of safety. Soon after the formation of the two organizations, the AEC began exerting pressure on the NCRP to formulate permissible dosages for workers in the nascent nuclear industry. Not only was this required to ensure worker safety but to protect the AEC from future liability. To legitimize the conditions in their facilities, the AEC was in need of backing from a respected scientific organization that had all the appearances of being independent. At the same time, it had to assure that standards of safety were not set so stringently that they would hamper the development of the nation's nuclear program. To seduce the NCRP into providing these services, the AEC first offered to accord the committee semiofficial status as a regulatory body if it would quickly publish standards. This offer was turned down. According to Taylor, the AEC then promised financial aid "'after we had demonstrated that we could do something for them'" (Caufield). Despite the desire to maintain appearances of being an independent agency, the NCRP was in a hopelessly incestuous relationship with the AEC. Half its members were government representatives. A great deal of the information it required to carry out its work was classified as top secret and access could only be attained

through AEC clearance. And the AEC was the chief beneficiary of the committee's work. Further, the NCRP was not able to maintain its financial independence. The AEC footed the tab for part of the NCRP's administrative and travel expenses.

In the years that followed its initial establishment, the NCRP received funding from many other sources. Karl Morgan, a health physicist during the Manhattan Project and participant on the NCRP, was outspoken on the influence these sources had on the development of radiation protection standards:

> A cursory glance at the National Council on Radiation Protection (NCRP), which set radiation protection standards in the United States, sheds light on whose hand fed those who set levels of permissible exposure. Past sources of income for the NCRP included the DOE [Department of Energy], Defense Nuclear Agency, Nuclear Regulatory Commission, US Navy, American College of Radiology, Electric Power Institute, Institute of Nuclear Power Operations, NASA, and the Radiological Society of North America. In truth, the NCRP relies upon the nuclear-industrial complex for most of its funding other than income from publication sales. Trust me, this fact does not escape NCRP members when they set standards for radiation exposure (Caufield).

When the NCRP got down to work after the war, their first order of business was to establish new radiation standards and to formulate policies for the new nuclear industry, on such matters as safe handling of radioactive material, environmental monitoring, the disposal of radioactive waste, and so forth. To pursue the necessary lines of research, eight subcommittees were established. In this way, many former scientists of the Manhattan Project came on board as advisors to the establishment of safety standards. The most important of the subcommittees formed were Subcommittee One, charged with reevaluating the currently accepted standard for radiation received external to the body by x-ray and gamma ray exposure, and Subcommittee Two, whose agenda was to formulate new standards for internal contamination by the plethora of radionuclides that had been born into the world in the nuclear reactors of the Manhattan Project.

Subcommittee One was headed by Gioacchino Failla, a physicist at Memorial Hospital in New York. The work of this committee focused on the accumulating evidence that the 1934 tolerance dose of 0.1 roentgen (0.1 rem) of x-ray/gamma irradiation per day was too high. By the end of 1947, Failla's committee recommended that the dose for external exposure be cut in half to 0.05 rem per day, with the maximum permissible dose for a week readjusted to 0.3 rem. Before the official adoption of this new standard, Taylor

queried the nuclear industry as to whether or not the new standards would in any way impede their program. The answer they gave is most telling of the philosophy of the NCRP:

> Ultimately, the committee settled on a figure that the nascent nuclear industry would accept. "We found out from the atomic energy industry that they didn't care [if we lowered the limit to 0.3 rem per week]," explained Lauriston Taylor. "It wouldn't interfere with their operations, so we lowered it" (Caufield).

The problem of developing standards for isotopes undergoing radioactive decay inside the human body was an entirely different problem from merely revising the standards for external exposure and required much more time. Prior to the Manhattan Project, the possibility of internal contamination to humans was limited to select, small populations and only by a few radionuclides. Radium was used in medicine and industry. Uranium and radon were a hazard to miners. With the discovery of artificial radioactivity in 1934 and the development of the cyclotron, radionuclides that did not occur naturally on the earth began to be produced and used in biomedical research. The Berkeley cyclotron was the primary source of artificially produced radionuclides for civilian research prior to and during World War II. When the Manhattan Project was well under way, radionuclides for research were also being produced secretly in the nuclear reactor in Oak Ridge, Tennessee, and purified there at Clinton Laboratories. In order to maintain the secrecy of their origin, these radionuclides were shipped first to Berkeley and from there distributed to labs throughout the country. In 1946, the newly established Atomic Energy Commission initiated a program promoting peaceful applications of the atom and openly offered the radionuclides produced in Oak Ridge to interested scientists. As intended, easy availability rapidly accelerated research. In the first year, 1,100 shipments of radionuclides were shipped from Oak Ridge to 160 research centers. Two years later, Abbott Laboratories also began distributing radioisotopes. The ensuing research delineated the physical characteristics of each radionuclide and the behavior of each when introduced into animal and human subjects. Medical researchers sought for any clue in their studies that would indicate the possible usefulness of a radionuclide in tracer studies, diagnostics, or treatment. The sudden proliferation of novel radionuclides created an urgency for the establishment of safety standards for each internal contaminant. This was a major focus after the war for the advancement of radiation protection.

All the information furnished in this chapter up to this point has been required background material and preparation for understanding the work conducted by Subcommittee Two. This committee was charged with the setting of radiation protection standards for radioactive material deposited in the interior of the human body through inhalation, inges-

tion, absorption, or uptake via skin lesions and wounds. Subcommittee Two pursued its work with the utmost integrity and succeeded in creating a system, expedient at the time, for establishing safety standards for internal contamination. Only many years later was their work subverted and transformed into a system of lies to cover up the true hazards to life produced by the release of radioactivity into the environment.

Subcommittee Two was chaired by Karl Morgan, who later presided for fourteen years over the committee on internal emitters for the ICRP. Morgan worked as a health physicist at Oak Ridge during the Manhattan Project and was employed there for twenty-nine years after the war. He cofounded the Health Physics Society and served as its first president. He is frequently referred to as the "father of health physics." In his later years, he became a controversial figure. He openly spoke out about the increased risks from unnecessary medical x-rays and advocated cutting the accepted standards for permissible radiation dosages by half. The nuclear establishment labeled him a "rogue physicist" and marginalized him. He is quoted as having said: "I feel like a father who is ashamed of his children."

When Subcommittee Two first met in September 1947, the challenge facing its members was daunting. Hundreds of novel radionuclides that had never before existed on the face of the earth, at all or in appreciable quantities, were being created en masse in the nuclear reactors that were producing fuel for atomic bombs. These same radionuclides were being created in the fireballs of atomic bomb detonations and scattered throughout the biosphere. Virtually nothing was known about their behavior once they gained access to the interior of the human body. Each possessed its own unique half-life. Each decayed in a unique manner. Each emitted different combinations of alpha, beta, and gamma radiation, and the energies transmitted by these radiations varied from one radioisotope to another. Each demonstrated a unique pattern of distribution throughout the body. Each showed a preference for an organ or tissue where it tended to accumulate. Each had its own rate of absorption, retention, and elimination. As a consequence of these factors and many others, each radionuclide presented its own unique toxicological and radiological hazard. What further complicated understanding was the problem of how to assess the combined hazard to a victim when more than one radioisotope was incorporated into the interior of the body at the same time. The major conundrum facing Subcommittee Two was how to proceed.

As a model for success in their endeavor, the committee had before them the example of radium. But therein lay the problem. The first standard for a permissible body burden of radium was not formulated with any scientific accuracy until well over forty years after that radionuclide's initial discovery. This successful standard was based primarily on

direct observation of internally contaminated individuals who later developed overt symptoms of disease or signs of injury. Once such a person was identified, the quantity of radionuclide taken up within their body was established and then compared to that of other individuals who lived or worked in a similar situation but who had internalized less and remained unharmed. By this means, estimates could be derived as to what levels of internal contamination were presumably safe. As further data accumulated, these initial judgments could be adjusted as required. This same approach worked for establishing the first standards for uranium and radon inhalation in mines. There was also reliable information, again derived from direct experience, about radium-224, used for therapeutic purposes in Germany between 1944 and 1951, and thorium-232, known as Thorotrast, used between 1930 and 1950 in patients to produce better contrast in x-rays. In addition, there were the human radiation experiments involving plutonium.

The members of Subcommittee Two recognized that standards for all the new radionuclides created by nuclear fission could not possibly be derived by direct observation. Data on the physiological effects in humans of many of these radionuclides was completely lacking. Sufficient animal studies had not yet been performed. Comparison of effects to known radioisotopes was possible only in a limited number of cases. Years, if not decades, of research would be required to generate the vast amount of required information on the physical, chemical, and biological behavior of each radioisotope. Such a task would be monumental. Yet standards were needed quickly to offer guidelines for protection of workers in the nuclear industry. Some other approach was required for zeroing in on what constituted permissible levels for internal contaminants.

During the war, Karl Morgan and other physicists and medical personnel of the Manhattan Project had made first steps in developing a new methodology for calculating dosages for internal emitters. By the war's end, they had succeeded in calculating the dose of radiation for seventeen radioisotopes in various chemical forms that would be delivered to the tissues they were likely to be deposited in once internalized. The methodology for these calculations was further developed after the War at three conferences on internal dosimetry held in 1949, 1950, and 1953. These meetings came to be known as the Tri-Partite Conferences in reference to the attending representatives who came from the three countries that had worked closely during the war in the study of radionuclides, namely Canada, the United Kingdom, and the United States. Many who attended these conferences were former participants in the Health Division of the Manhattan Project and later were members of Subcommittee Two. This is both interesting and important. The foundation of today's approach to internal contamination by radionuclides was forged by the subculture of physicists and medical personnel who built the first atomic bomb. Their mentality and orientation toward radiation safety evolved while they were immersed in fabricat-

ing weapons of mass destruction. While supporting the development of a weapon for the annihilation of masses of humanity, they simultaneously occupied themselves with developing safety standards to protect the world from the menace they were creating. In the post-war world, these same individuals entrusted themselves with becoming the guardians for all of humanity in their prescription of what constituted a permissible dose of radiation. This is an excellent example of the genocidal mentality referred to elsewhere in this book. To a healthy mind, true radiation safety would entail refraining from building weapons of mass destruction altogether.

The scientists participating in the Tri-Partite Conferences built upon the existing methodology for calculating the dosages for internal emitters and carried it further. What they created was a "computational system" based on mathematical modeling. This computational approach allowed them to calculate dosages from internal emitters and permissible levels of exposure without having to rely on direct observation and experimentation. In ensuing years, as new experimental findings and data from direct observation became available, this information was fed into the system to further refine and improve it. The methodology relied upon today by the agencies setting standards for internal emitters use this same computational approach, with updated modifications, to determine for the public what constitutes a permissible dosage of radiation emitted by radioactive atoms gaining entrance into the human body.

Many of the participants of the Tri-Partite Conferences later served on Subcommittee Two of the NCRP. These same people sat on a similar subcommittee studying internal emitters for the ICRP which Lauriston Taylor was instrumental in resurrecting in 1953. This is how the computational approach took root in these two agencies. The results of the Tri-Partite Conferences were transplanted into the NCRP and then into the ICRP, and these organizations became a clearing-house from which information about radiation safety was distributed throughout the world.

For the computational system to be effectively applied, a great deal of background data had to be assembled. First, the physical properties of each radionuclide had to be determined. The most important of these was the rate of decay, the type of radiation each emitted (alpha or beta plus the gamma ray that frequently accompanied each decay), and the energy this radiation would transfer to the organ of retention. As mentioned earlier, each type of radiation created different degrees of biological effect, and this information was included in establishing the quantity of energy each decaying atom would transmit to its surroundings. Also necessary was knowledge of the behavior of each radionuclide once introduced into the body. Of particular importance was the retention kinetics of each: where did it go, how long did it stay, and over what period was it released. Numbers were

also needed to represent the fraction of the radionuclide that passed from the gastrointestinal tract or lung into the blood, the fraction in the blood transferred to the critical organ, the fraction passing into the critical organ compared to the remaining fraction in the total body, and the fraction of that taken into the body that actually was retained in the critical organ. By knowing such patterns of distribution, calculations could be made to determine the dose delivered by each radionuclide to each organ or tissue and its maximum permissible body burden.

For the computational approach developed by the Tri-Partite Conferences to be applicable for all radioisotopes in all human beings, it was necessary to formulate a conceptual model of the human body that would be representative of all people. This model became known as "Reference Man", or more commonly, "Standard Man". This ideal human was "regarded as weighing 70 kg, being 170 cm high, between twenty and thirty years old, a Caucasian of Western European habit or custom and living in a climate with an average temperature of 10^{o} to 20^{o}" (Stannard). The inclusion of information on custom and climate was to set parameters for average water intake and typical diet. The tissues of the body of Standard Man were considered to have an average density equivalent to that of water. Basically, Standard Man was conceptualized as a 70 kg mass of water. An average mass for each organ in the body was derived mathematically and conceptualized as a smaller mass of water residing within the larger mass of water.

The successful application of the computational system for deriving safety standards hinged on a knowledge of how much radiation each organ or the body as a whole could be exposed to without causing any ill effect. With no prior knowledge of the behavior of the majority of radionuclides once inside the body, how was determination of a permissible dose possible? Members of Subcommittee Two were forced to rely on the vast body of knowledge that had accumulated over previous decades of the body's response to x-rays, i.e., EXTERNAL RADIATION. To quote *Radioactivity and Health: A History*:

> It should be noted that no cognizance is given in the system [computational system] to the nature of the biological effect being protected against. The limiting dose rate was determined by groups espousing basic radiation protection criteria. They arrived at their conclusions largely on the basis of work with *external radiation sources* [italics added], except for the bone seekers. They applied their best judgment to the biological data and set exposure levels for the most sensitive functions (Stannard).

The phenomenon of electromagnetic energy interacting with matter is what Manhattan Project scientists used for formulating a general model of what transpires when

any type of radiation interacts with matter. So effective was their conceptualization in explaining the impact of x-rays and gamma rays on the body that they did not hesitate to apply the same model for explaining the biological impact of alpha and beta particles plus gamma rays released in the interior of the body by decaying radionuclides. They carried this thinking into the Tri-Partite Conferences after the war and made it a cornerstone of the computational approach for determining dosages of radiation delivered by internal emitters. The validity of the entire model of radiation effects in man that they were constructing hinged on the validity of the foundational assumption that the biological effect of internal radioactive decay could be modeled on the biological effect of external irradiation.

After a half century of radiology, a substantial body of knowledge had accumulated about the effects to different organs, and the body as a whole, from different quantities and intensities of x-rays delivered at different rates from the exterior of the body. Based on this experience with external radiation sources, those working on the problem of internal emitters assigned a maximum permissible dose and dose rate to each organ of the body of Standard Man. The assumption was then made that each organ could safely absorb the same quantity of energy delivered from decaying radioisotopes embedded in the organ as it could safely absorb from x-rays delivered from outside the body. To the thinking of the time, what was important was the amount of energy delivered. For the computational system to work, what was required was a knowledge of how much energy was being deposited per unit mass of tissue under consideration. It was this point of view that allowed members of Subcommittee Two to base their work on internal emitters upon the previous research on external irradiation.

A simplified, hypothetical example will suffice to illustrate the type of calculations being performed in the absence of direct observation and research on the behavior of each radionuclide once inside the body. Suppose the permissible dose from exposure to x-rays has been established for an organ. This quantity represents the amount of energy that can be transferred to the atomic structure of that organ with no manifestation of any ill effect. That knowledge is then used as a baseline for calculating what quantity of a particular radionuclide could be taken up by the organ without manifesting any signs of injury. *To simplify the kinetics involved, the assumption was made that the internal contaminants were distributing the energy emitted from radioactive decay throughout the entire organ*. In this way, an equivalency was visualized between external and internal radiation. Each form of radiation was delivering the same quantity of energy to the same mass of tissue. Consequently, there was no reason not to apply what was known of external irradiation to the problem of internal radiation. Although in time a host of modifying factors were introduced to account for differences in the way the different types of radiation were delivered and the type of biological effect each produced, these had no effect in displacing the fundamental assumptions that

the transfer of energy was the essential characteristic of the interaction of radiation with the human body and that the energy delivered to an organ could be treated as if it were evenly distributed throughout the mass of that organ.

To return to the work of Subcommittee Two, once permissible dosages were calculated for each radionuclide, secondary standards were mathematically derived for the maximum permissible concentration of each radionuclide in air and water. The need for these safety standards was based on the idea that the only way to prevent a person from accumulating a hazardous dosage of internal emitters was to control the environment in which the person worked or dwelt in so as to limit hazardous accumulation of the radionuclide(s) in the air being breathed and in the food/water being ingested. A person dwelling in an environment where air and water did not exceed the maximum permissible concentrations would not accumulate levels of the radioisotope that would deliver a dose of radiation greater than the permissible dose. A working lifetime was considered to be 50 years. Intake for each radionuclide was presumed to happen continuously, either for a work week of 40 hours or continuously throughout a week's 168 hours. Limits were then established for the maximum permissible concentration for each radionuclide in water and air so that a worker exposed to these levels would never accumulate the maximum permissible dose to an organ over his working lifetime or at a rate that presumably would be hazardous.

In a nutshell, this is the computational method developed at the Tri-Partite Conferences and used by Subcommittee Two in establishing permissible limits for internal emitters. Although undergoing extensive revision over the years as new information became available, this mathematical approach to calculating permissible dosages still forms the backbone of radiation safety today. It is Health Physics 101. It is unquestioned orthodoxy in regards to the proper way of calculating the radiation transmitted to biological structures from internalized radioactivity.

For the non-specialist struggling to make sense of the technical material just presented, a single image is all that is required to follow the essence of the discussion. Visualize a person inhaling some quantity of a radioisotope. Microscopic particles of that radioisotope pass into his bloodstream and by metabolic processes within the body are transferred to the critical organ where they subsequently become lodged for a period of time within the cells of that organ. While retained there, some of the atoms undergo radioactive decay and radiate alpha or beta particles, depending on the isotope, and usually an accompanying gamma ray which can be visualized as a photon, a massless packet of energy. The energy transmitted by the nuclear particles and the photon for each radioisotope are known physical quantities as is the rate of decay for each radionuclide. Standard Man provides a reference for the mass of each organ. As the energy of radioactive decay is emitted, that ener-

gy is transferred to the electrons of the atoms making up the cells of the organ of deposition. If an estimate can be made of the amount of the radioisotope initially inhaled, the computational method can be used to calculate the amount of energy transmitted to the molecular structures making up the organ. The assumption is made that that energy is uniformly distributed to the mass of the organ, and by this means, the organ dose can be determined.

The original intention of Subcommittee Two, formulated in 1947, was to recommend maximum permissible concentrations in air, water, and the human body for twenty biologically significant radioisotopes. When their final report was published in 1953, and a similar report published by the ICRP in 1955, values had been calculated for 96 radioisotopes. Work continued throughout the decade, and both committees published comprehensive reports in 1959 which included information on approximately 215 radionuclides and 255 values for maximum permissible concentrations.

The work of Subcommittee Two was a milestone in human understanding. It provided a relatively simple methodology for quantifying dosages of radiation delivered to the interior of the body by radioisotopes. Further, it established urgently needed standards of what might constitute nonhazardous levels for a variety of radioisotopes. The new guidelines provided the framework for all future animal and human studies into the toxicology of radioactive materials. Subsequent study began to demarcate what dosages of each radioisotope were necessary to produce detectable alterations at every level of biological systems from the molecular to the cellular to the histological to the systemic. With protection standards in place, researchers could work in apparent safety in the development of such disciplines as nuclear medicine, radiation therapy, and radiobiology. Then as now, what remained a fundamental priority was to validate the accuracy of the computational system to determine whether or not it successfully modeled the actual biological impact of internalized radioactivity.

Before concluding this brief history of the development of radiation protection standards for internal emitters, one final point needs emphasis. Every living creature on the earth requires protection from mankind's experimentation with radiation. Without debate, this responsibility was assumed by the NCRP and the ICRP. These institutions were never truly separate or independent, and the membership of both heavily overlapped. Lauriston Taylor was deeply involved in the establishment of both organizations. Gioacchino Failla and Karl Morgan were chairmen for the subcommittees on external and internal radiation for both the NCRP and the ICRP. Other US representatives to the ICRP were also members of the NCRP. As a result of this cross-pollination, no opportunity ever existed for an alternative point of view to evolve in regards to what constituted radiation safety and what

was judged to be permissible exposure.

> The Chair of the NCRP, Lauriston Taylor, was instrumental in setting up an international version of the NCRP, perhaps to divert attention from the clear evidence that the NCRP was associated with the development of nuclear technology in the USA and also perhaps to suggest that there was some independent international agreement over the risk factors for radiation (ECRR).
>
> Taylor was a member of the ICRP committee and the NCRP Chairman at the same time. The NCRP committees One and Two were duplicated on the ICRP with the identical chairmen, Failla and Morgan. The interpenetration of personnel between these two bodies was a precedent to a similar movement of personnel between the risk agencies of the present day. The present Chair of the ICRP is also the Director of the UK National Radiological Protection Board (NRPB). The two organizations have other personnel in common and there are also overlaps between them and UNSCEAR [United Nations Scientific Committee on the Effects of Atomic Radiation] and the BEIR VII committee [Biological Effects of Ionizing Radiation Committee, originally funded by the Rockefeller Foundation in 1955, and now organized under the auspices of the National Research Council of the National Academy of Sciences.] This has not prevented the NRPB from telling the UK's regulator, the Environment Agency, that UNSCEAR and ICRP are 'constituted entirely separately', a statement which the Environment Agency accepted. Thus credibility for statements on risk is spuriously acquired by organizations citing other organizations, but it can be seen as a consequence of the fact that they all have their origins in the same development and the same model: the NCRP/ICRP postwar process. This black box has never been properly opened and examined (ECRR).

The NCRP/ICRP black box is impenetrable. The public has no access into the hearts of those who have served on these committees, the discussions that have gone on behind closed doors, the compromises that may have been made in radiation safety for the benefit of government nuclear programs and the nuclear industry. However, the international radiation protection agencies have left within the public domain a penetrable artifact of their true intentions and their true allegiances, i.e., their system of evaluating the risks of radiation exposure and their standards of what constitutes a "permissible" dose of radiation. As the gospel of this book loudly proclaims, "By their deeds you will know them."

Radiation Safety in Its Infancy: 1895-1953

You will know them by the fruits of their deeds. The reach of the Cult of Nuclearists and the services performed on their behalf by the radiation protection community is unmistakably written within the system currently relied upon to evaluate the hazards of internal contamination. Through a study of this system, glaring flaws become evident, intentionally left uncorrected to serve the political agenda of covering up the true impact to health from radiation released into the environment.

6

The Most Heinous Crime in History: The Betrayal of Mankind by the Radiation Protection Agencies

You can't underestimate the importance of public relations when you are trying to dump radioactive material on people [the transcript noted laughter at this point], and we worked at it strenuously.[1]

Oliver R. Placak

Science is a dynamic human enterprise. Achievements in understanding are frequently tentative advances which require reformulation as further knowledge is acquired. In fact, this is one of the distinguishing characteristics of science that separate it from all forms of dogmatism. The scientific method, when applied with integrity, invites evolution in understanding as new discoveries are made. This should have been the case with the computational model based on a transfer of energy from internalized radionuclides to whole organ masses. But the process was subverted. Like physics during the early part of the twentieth century, biology underwent a dramatic revolution beginning in the 1950s. The new realities which emerged underscored fundamental errors in some of the basic

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[1] This quote appears in *Fallout: An American Nuclear Tragedy* by P.L. Fradkin. Oliver R. Placak was a radiation monitor for the Public Health Service who worked offsite of the Nevada Test Site during the period of atmospheric nuclear weapon testing. He made this statement in 1980 during a meeting convened by the Department of Energy to gain information to refute allegations in the lawsuit *Irene Allen v. The United States of America* (filed August 30, 1979) that fallout was responsible for producing cancer in people living downwind of the tests.

assumptions underlying the computational approach. Nevertheless, regulatory agencies have made no effort to correct the inherent flaws in their system which they continue to rely upon in gauging the biological impact of internal emitters and which remains the basis of internationally accepted standards of what constitutes permissible radiation exposure.

In most other scientific matters, a debate over safety would be entrusted to specialists in the field. Experimentation and the scientific method would be the final arbitrator between any rivalry of opinions. But this can no longer be the case with the study of internal contamination. The field of radiation protection has been heavily infiltrated and compromised by those with a vested interest in ensuring the proliferation of nuclear and radiological weapons and commercial nuclear reactors. A politically motivated international system of standard setting agencies, upholding antiquated models of the biological effects of ionizing radiation, has asserted itself as the voice of authority in the field of radiation protection. Governments, in turn, depend on the flaws within these models to legitimize the safety of their nuclear programs and conceal the detrimental biological effects these programs impart to unsuspecting populations. Under these circumstances, it would be foolish to believe that objective, disinterested science is representing the best interest of humanity. As long as the trained professionals remain remiss in their duty to counter the misdeeds of regulatory agencies and government, no alternative remains but to open to the public forum the ever so important issue of radiation safety.

The Trial of the Cult of Nuclearists

Hear Ye! Hear Ye! At long last, the time has come to convene the court of public opinion to try the Cult of Nuclearists for their crimes against humanity. They are charged with the crime of fraud, momentous fraud, which has been a shield for an unprecedented degradation of the earth and a creeping debilitation in the health of all people and all living things. What follows is the case for the prosecution. Let the people judge.

Exhibit A

The entire system that has evolved to safeguard the welfare of humanity is ultimately grounded on one fundamental idea: The essential feature of the interaction of radiation with biological systems is the transfer of energy from its source to the medium in which it is absorbed, and the degree of injury is proportional to the amount of energy transferred. This idea was advanced by physicists attempting to conceptualize biological realities, reali-

ties of which they had very little knowledge. Biology, however, is governed by its own laws, laws different from those falling within the province of physics. When now queried by current understanding, biology responds that this central idea is erroneous. **The neat concept of energy transfer is largely irrelevant to the biological response to ionizing radiation**.

Before proceeding, be forewarned. What follows is heresy. It is an unwelcome intrusion on the tyrannical paradigm that dictates how human beings are supposed to understand the interaction of radiation with living systems. Within the modern knowledge base, this paradigm is not only archaic but false, artificially propped up and perpetuated by the nuclear establishment. Although what follows defies orthodoxy, this does not equate with an absence of scientific merit. It is soundly grounded in modern research. It is gaining popularity as courageous and outspoken scientists step out of the shadows and forthrightly question why rates of cancer and mortality associated with internal exposure to radioisotopes are so much greater than that predicted by the currently accepted models of risk upheld by the ICRP models.[2]

To fire a shot across the bow of the Cult of Nuclearists, let the discussion begin with a quotation from *Radiation Protection Dosimetry: A Radical Reappraisal*: "**the amount of kinetic energy transferred in each collision** [between a charged particle and the molecular components of a cell] **plays no role in the production of radiation effects in mammalian cells**".

Flawed thinking is the foundation upon which current models of radiation protection are built. The essential problem dates back to the first attempts to come to terms with the meaning of dosage as it applies to radiation. The roentgen was adopted as the unit of measure of exposure. It represented the quantity of ionization produced in air by photons emitted by an x-ray machine. At issue was how to translate this quantity of effect in air into a meaningful concept of biological effect once that energy penetrated into the human body. The model that was eventually adopted by physicists was analogous to the model adopted to explain the radiation of heat. When ionizing radiation penetrates a mass, the incident energy is conceptualized as being uniformly distributed throughout the entire mass. The unit of absorbed dose gave expression to this view of incident energy as averaged throughout the absorbing mass. The rad is an expression of ergs *per* gram. This concept seems suitable for thinking about the absorption of radiation by inanimate objects. However,

[2] Good background material for this discussion can be found at the following websites:
Committee Examining Radiation Risks from Internal Emitters - www.cerrie.org.
European Committee on Radiation Risk - www.euradcom.org.
Low Level Radiation Campaign - www.llrc.org.

when applied to ionizing radiation's interaction with living systems, the model shows its flaws:

> One need only consider the common fever in order to ponder the very high probability that the biological potency of ionizing radiation is related to its spatial concentration along tracks, rather than to its meager addition of energy to cells. A dose of 400 cGy (400 rads) is equivalent in heat to only 4.184×10^{-3} joules per gram of tissue — enough to provoke a mini-fever of 0.001 degree Centigrade — yet 400 cGy of ionizing radiation to the whole body, acutely delivered, will kill about half the humans exposed to it. (Gofman 1990)

In this example, the biological effects of ionizing radiation cannot be adequately modeled by simply dividing the quantity of energy by the mass into which it is deposited. That mode of thinking blinds one to the reality of how biological damage is actually induced by radiation. A living system is made up of cells. Impact on the functioning of these cells depends on how the energy is distributed in relationship to critical cellular structures:

> Generally, ionizations are not produced singly, but as double or triple events, known as clusters. Based on the assumption that an average of three ionizations occur per cluster, the figure of 100 eV/primary ionization is often used when discussing energy transfer. Even though the amount of energy involved in ionization appears very small, it tends to be very efficient and extremely lethal. If 100 eV/cluster were deposited in a sphere 30 angstroms in diameter, it would increase the temperature (locally) from 37^{o}C to approximately 80^{o}C. **Consequently, it is the distribution of the energy and not the total amount of deposited energy that is significant for cell inactivation** [emphasis added] (Holahan).

In his book *Wings of Death: Nuclear Pollution and Human Health*, Chris Busby totally destroys the reigning paradigm of energy transfer:

> Energy, however, can be transferred in a multitude of ways, and takes many forms; on its own, energy transfer is a totally useless measure of quality of effect. For example, one cup of boiling water at 100 degrees centigrade contains the same energy, the same number of Joules, as some ten times this quantity of water at the temperature of ten degrees. An energy transfer to a person of one waterthrow unit could encompass either a cupful of boiling water in the face or a buck-

> et of cold water: more information is needed before the health consequences can be assessed (Busby 1995).

This simple illustration highlights the shortcomings of the physics-based model of the biological effects of radiation. Energy can be transferred in many different ways. And equal quantities of energy can produce dramatically different effects depending upon *how they are delivered*. Acknowledgment of this simple fact necessitates a revision of the very foundation of current approaches to radiation protection:

> The last twenty years of developments in knowledge of cell biology have rendered obsolete the primitive understanding of radiation effects which is still used to underpin present laws of radiation safety. It is now apparent that we cannot continue to lump all radiation together and talk of "dose" as some physical quantity of transferred energy, as if sitting in front of a hot fire and absorbing the warmth of so many joules were equivalent to the same number of joules absorbed if we were to reach into the fire, withdraw a red-hot coal, and swallow it. The effects of radiation depend on the quality of that radiation and how it is delivered in space and time (Busby 1995).
>
> The energy transfer model for determining the effects of ionizing radiation starts out by postulating that so much energy transfer of ionizing radiation should produce proportional effect on living tissue. The shortcomings of such a facile hypothesis soon became apparent. The first obvious weakness was its inability to distinguish between the biological effect of different types of radiation: alpha, beta, gamma.
>
> Experiments in cell cultures made it clear that the effects of these three types of radiation [alpha, beta, gamma] were different: it was not the quantity of the radiation that explained the results, but its quality. Although the three types of radiation had been distinguished in theoretical physics, pioneers of radiation assumed that their harmful effects would be relative to the amount of energy each carried, rather than the nature of its irradiation effect (Busby 1995).

Radiation delivered to the body externally in the form of x-rays and gamma rays and radiation delivered to the body internally by the emission of alpha and beta particles from decaying radioisotopes are fundamentally different phenomena. The attempt to liken them by focusing on the fact that they both transmit energy disguises the fact that they differ in terms of the biological effects they produce. The model of energy transfer arose to explain the effects of x-rays impinging on the body from the outside. This model was ade-

quate for explaining relatively high doses of radiation. The large quantity of photons involved in the interaction are distributed throughout the mass that absorbs them. The primary ionizations created when the photons interact with orbital electrons throughout the target and the secondary ionizations caused when these liberated electrons go on to ionize other atoms tend to be spatially removed from each other in a sparse pattern of molecular disruption. As an abstraction, the idea of a uniform distribution of effect throughout the absorbing mass is not unreasonable. Alpha and beta particles from internal emitters not uniformly distributed, however, produce a different pattern of molecular damage within cells or within tissue. Their range of travel is minute, and they deposit all of their energy in a dense pattern of ionization in a small volume of cells. A "hot particle", a particle composed of a huge number of radioactive atoms, acts as a point source or hotspot, perpetually emanating radiation to the same critical cellular molecular structures in their immediate vicinity throughout the time they are retained within the body. This is the rationale for the hot coal analogy mentioned above. Being warmed by a fire is different from swallowing a hot coal, though the same amount of energy might be transferred. The two phenomena create different patterns of biological effect.

The model for external radiation that came to dominate thinking does in fact approximate reality to a certain degree. This is not because the essence of the phenomenon is, as visualized in the model, a transfer of energy throughout the target mass, but because at relatively high doses individual cells begin receiving multiple hits in critical structures and become increasingly vulnerable to functional alteration. A dense pattern of ionization in proximity to critical cellular structures is created which mirrors that created by alpha particles, and to a lesser degree beta particles, released by internal emitters. The key phenomenon is the location of ionizing events within the cell, not simply the amount of energy transferred. At high doses of external radiation, the differences between irradiation from the outside and internal exposure become blurred. Dense patterns of ionization within individual cells are created by both types of exposure. Biological damage becomes proportional to the dosage and the quantity of energy is predictive of the damage. Thus, the apparent triumph of the physics-based model. **The fundamental problem with the model is that it breaks down at low doses of radiation.** When the dosage delivered by photons external to the body is so low than each cell fails to be hit at least once, the idea of uniform distribution of energy within the target mass falters. At these low doses, the pattern of ionization created by external radiation and the hazard this poses cannot be likened to that produced by decaying radionuclides which are creating dense patterns of ionization and extensive local chemical disruption in individual cells. At low doses, the equivalent energy delivered by x-rays or gamma rays externally and that delivered by alpha and beta particles internally produce different patterns of chemical disruption to individual cells. As a consequence, low dose effects from external irradiation cannot be used to pre-

dict effects from internal contamination. The simple conclusion that, dose for dose, internal emitters may produce more negative biological effect than external irradiation is a calamitous conclusion for the nuclear establishment and will ignite vehement rebuttal. The whole basis for discounting the hazards from radionuclides emitted from nuclear installations or the detrimental effects of depleted uranium weapons is grounded on the purported equivalency between external and internal radiation based on the amount of energy they deliver. The qualitative difference in their capacity for promoting harmful effects to individual cells is conveniently ignored.

The current model attempts to account for the differences between the various types of radiation and their biological effects. Modifying factors have been introduced to shore up the reigning paradigm that energy transfer is the central phenomenon in radiation's interaction with living systems. For instance, the concept of *linear energy transfer* (LET) was formulated to account for the density of ionization produced by different types of radiation along their path of travel and the amount of electron-volts deposited per micrometer. The *relative biological effectiveness* (RBE) of different types of radiation, later replaced by the *quality factor* (QF), was a modifying factor added to calculations to account for the varying degrees of biological effect created by equal quantities of energy when delivered by different types of radiation. A *distribution factor* (DF) was another modifying factor introduced into calculations to account for the biological effect created by internally incorporated radioisotopes distributed nonuniformly throughout the target organ. It is essential to understand that these kinds of modifying factors were patched on to the prevailing model of energy transfer to rescue it from irrelevance by bringing it more into line with observed biological effects. These quick-fix measures, however, never addressed one central underlying flaw in the reigning paradigm. It is not grounded in biology, in the way cells actually respond to radiation!

The reigning paradigm is out of step with the current knowledge base. It is completely inadequate for modeling the effects of low-level radiation on the cellular level. The problem is that it is grounded on an "unsound premise." As mentioned in *Radiation Protection Dosimetry: A Radical Reappraisal*: "In the present context, the unsound premise is that absorbed dose is a fundamental concept that can be used as an effective predicator of radiation effects." Simmons and Watt then continue:

> Criticisms of the use of absorbed dose as a basis for assessing the effects of low levels of radiation are not new. At the 17th meeting of the NCRP in 1981, V. Bond, the Head of the Medical Department of

> the Brookhaven National Laboratory, observed that for stochastic[3] processes such as the induction of cancer at low levels of radiation, it is the effect within a cell (or a small number of cells) that is important. However, because at low levels of radiation (i.e., those of significance in radiation protection) a large proportion of the cells will have received no radiation, the mean dose per cell represented by the average tissue dose is not the same as the mean dose per dosed cell. A better quantity to use in this context is the fluence of charged particles through the critical volumes. Only when all the cells have received at least one hit (i.e., at "doses" of ~ 10 cGy [10 rad] for low-LET radiation and ~ 1 Gy [100 rad] for high-LET radiation) does dose become a suitable surrogate for charged-particle fluence.

To translate, the current model is adequate to explain radiation effects as long as the radiation dose received is great enough that the critical volume of each cell of the target [i.e., the cell nucleus] receives at least one hit by tracks of ionization laid down by alpha, beta, or gamma radiation. In doses smaller than this, a better predictor of biological effects is the fluence[4] of charged particles passing through the nuclei of the cells actually hit. Why is this? When low levels of radiation traverse tissue, not all cells are hit. Thus, the averaging of energy over large volumes is an erroneous concept. Biological effect is only induced in cells that are actually hit. Of those cells that are hit, the greater the number of tracks of ionization passing through the nucleus, the greater the likelihood for irreparable damage to critical cellular structures such as the DNA molecules. Thus, the fluence of charged particles is the fundamental phenomenon in gauging radiation effects. As Simmons and Watt explain, "Energy deposited is not the cause of an interaction; it is a secondary effect. The interaction is best described by fluence and cross section." From this point of view, dose "can be expressed as 'hits per unit volume or mass' or 'passage of particles per unit area'" (Simmons and Watt). Here physics and biology merge in a successful model that accurately depicts what takes place when radiation interacts with living systems composed of individual cells.

In the opinion of many radiobiologists, the most critical lesion created in a cell traversed by radiation is a double-strand break (dsb) in the DNA molecule. Single-strand breaks along one half of the double-helix molecule are effectively repaired by cellular mechanisms. Two breaks, each occurring along each half of the double helix, are much less likely to be accurately repaired. Such a lesion either goes unrepaired or is misrepaired.

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[3] The outcome of stochastic processes involve chance or probability. Their end result is not fixed or causally determined.

[4] The term "fluence" refers to the number of charged particles traversing a given target volume per unit time..

This can lead to cell death or various types of mutation that may or may not be lethal to the cell. Mutations within cells that do survive may be the precursor to a cancer. The distance between the two strands of a DNA molecule is approximately 2 nanometers (2 billionths of a meter). There are a number of patterns of radiation fluence that can be responsible for creating successive ionizations within this critical 2 nm distance. At high doses of gamma irradiation, a number of tracks may intersect the same cell nucleus and successfully cause breakage in the two arms of the same DNA molecule. As dosage decreases, the likelihood of double-strand breaks diminishes. It is at this point that the current model of energy effects begins to break down. (Although the dose delivered by photons makes dsbs unlikely, an equivalent dose delivered by marauding alpha particles still retains the capacity for creating dsbs.) A second possible initiator of a double-strand break is a decelerating electron coming to the end of its track and ionizing both strands of a DNA molecule. The geometry of this type of event makes the probability of its occurring relatively low. A third and very effective cause of double-strand breaks is a heavy particle such as an alpha particle. Its dense pattern of ionization permits it to breach, at a single blow, both strands of the double helix. This is what makes alpha-emitting radionuclides so potentially hazardous. Just one alpha particle has the capacity of creating a dsb.

So far, what has been mentioned are double-strand breaks created by direct hits to the DNA molecule. Indirect hits can also contribute to double-strand breaks. The most frequent type of molecule to be ionized in a cell from radiation is water. This can lead to the formation of free radicals which can diffuse up to a distance of about 15 nm from the particle path that created it. Created in close enough proximity to the DNA molecule, the free radical can induce rupture along one of the strands, creating a point mutation. Similarly, the hydroxyl radical (OH) produced from the ionization of water can diffuse 2 to 3 nm and promote chemical rupture in a DNA strand. Thus, it is the combination of both direct and indirect hits to the nucleus that combine to create double-strand breaks.

> The radiation track must, so to speak, match the 'template' of the strands of the DNA for an effective interaction to occur. Those interactions which occur at positions not so matched will have no effects, a situation that accounts for the irrelevance of energy transfer. There are on average ~15 pairs of strands at risk across the cell nucleus. The observed saturation cross section depends on the number of target DNA segments penetrated (determined by the particle's projected range) and the interaction spacing along the relevant track (Simmons and Watt).

Under this scheme, the probability of hits created by the respective fluences of variously charged particles delivered at different rates becomes a basis for establishing relative

hazard.

> The conclusion to be drawn is that the basic mechanism of radiation damage to normal mammalian cells is the correlation of two ionizations, which are spaced at about 1.5 to 2 nm along single-particle tracks in the relevant charged-particle spectrum, with the similarly spaced strands of the intranuclear DNA. The biological effects discussed are found to depend on the number of such paired interaction events, which are independent of the energy transfer (Simmons and Watt).

Within this new paradigm, it is the breakage of the chemical bonds of the two strands of a DNA molecule that is critical, AND, for this to occur, no more energy is required than the binding energy of these two bonds. Thus, the old paradigm, in which radiation effects were pegged to total energy absorbed, mistakes the fundamental phenomenon in the interaction of radiation with living systems.

> If one accepts the argument, based on experimental evidence, that the amount of energy transfer in excess of bond energies is irrelevant to the induction of radiation effects, then it is fundamentally wrong to use energy deposition as a quantifying parameter.
>
> Two ionizations, if appropriately placed, are sufficient to break two single strands of the DNA whether the energy transfer is 10 eV or 1 MeV. All the evidence obtained here points to the conclusion that it is the *number* of events (double-strand breaks in the DNA) caused by correlated pairs of ionizations that matter, not the energy transfer. Thus, two ionizations produced in the critical volume of a DNA segment need not induce a dsb. To do this the ionizations produced by the track must be correlated with the strands of DNA, like a template. If this is correct, then it would invalidate, on conceptual grounds, the use of volume quantities such as absorbed dose; the quality parameters ionization density and restricted LET; and the microdose quantities, linear energy and specific energy density, because these quantities include the interactions of low-energy delta electrons (Simmons and Watt).

Simmons and Watt title their book *Radiation Protection Dosimetry: A Radical Reappraisal*. Their proposal for a new paradigm in understanding radiation effects is both unorthodox

and revolutionary. It challenges the very foundation of current thinking on how to best conceptualize what transpires when radiation interacts with life. It has been presented here in order to highlight the inadequacies of the reigning paradigm. It is evidence that the knowledge base has expanded tremendously since the Tri-Partite Conferences. Further, it is evidence of how antiquated the currently accepted model of radiation effects has become. The puzzle that must be unraveled is why such an outdated, inaccurate model continues to be used to protect mankind from exposure to low levels to ionizing radiation. The answer to this question will be addressed in Exhibit E.

Exhibit B

Dosages are calculated on the basis of the amount of energy transferred to a biological system. The risk to normal function posed by those dosages are similarly pegged to the amount of energy absorbed. From Exhibit A, it should have become obvious that this system is in need of revision. However, even within the currently adopted paradigm, a fundamental problem exists in the accepted methodology for calculating how much radiation a person receives from radioactive material deposited within the human body. As mentioned earlier in this chapter, the dose delivered to an organ is derived by averaging the amount of radiation emitted by internal contaminants over the entire mass of the organ in which they are deposited. Using external irradiation as a model, the physicists of the Manhattan Project postulated that internal emitters would produce the same biological effect for the same amount of energy deposited by radioactive decay (with consideration given to the quality factor of each type of radiation). To capture this energy transfer in their mathematical calculations, the energy transmitted by alpha and beta particles during radioactive decay was averaged over the entire mass of the target organ to yield an organ dose. **The ICRP continues to this day to insist that this is the proper way of calculating dosages from internal emitters!**

Alpha and beta particles emitted by radioactive contaminants create dense, localized patterns of ionization within a microscopic volume of tissue. To treat these emissions as somehow impacting and transmitting an effect to the entire mass of an organ is a gross conceptual blunder that totally distorts the reality of what actually transpires on the cellular and molecular levels. As mentioned previously, alpha particles on average traverse no more than 30 to 40 microns, approximately 3 to 4 cell diameters. Beta particles can travel as far as millimeters, depending on their energy and the density of the tissue, traversing the distance of approximately one hundred cell diameters. When emitted from an atom undergoing radioactive decay, these particles travel along discrete tracks within a small volume of cells. Biological damage is produced within individual cells along these particle tracks. While in transit, they initiate the ionization of molecules only along their path of travel,

either hitting vital molecular cellular structures, such as the DNA molecule, or missing them altogether. Not all cells within the range of the particle are affected. Biological alteration occurs only in those cells that are hit by the particle. Cells that are missed by the particle suffer no injury. *With internal emitters, the unit of interest for gauging biological effects is individual cells, not whole masses of tissue*. This is particularly true for the induction of a cancer. Cancers arise from mutations within a single cell. This being the case, averaging the effect of a particle over an entire mass is ludicrous. Being a hit or miss phenomenon involving individual cells, how can the effect of an alpha or beta particle be averaged over the entire organ?

Chris Busby has been instrumental in highlighting the shortcomings of this physics-based averaging model which he speaks about at length in his book *Wings of Death* and in numerous other writings. On the website of the Low Level Radiation Campaign, a simple but effective illustration can be found that pinpoints the inadequacy of current practices for calculating the biological impact of internal emitters:

> The conventional approach of averaging the energy transfer from radioactive decay events across a whole organ or the entire body is like emptying a Colt 45 into a football stadium and averaging the effects of the 6 bullets across all the 25,000 spectators. The assumption that between them 25,000 people should be able to stop six bullets without any of them feeling more than a tap on the arm will not console the six grieving families.[5]

In this example, the 25,000 spectators are the cells of an organ. The six bullets are six alpha particles. By the averaging model, the energy from the velocity of the bullets is treated as equally distributed to all who feel no more than a tap as a result. But this model simply does not reflect the phenomenon. In reality, the full energy is absorbed by only six spectators with catastrophic consequences. In terms of biological effect, it makes no sense to speak of the impact of six alpha particles distributed over 25,000 cells. Only the individual cells hit will suffer biological damage. The remainder will escape unscathed. The dose is not received by the whole organ. It is absorbed completely by only a handful of cells.

For the incredulous readers, shaking their heads in disbelief that the international radiation protection community calculates biological impact of internal emitters by such hocus pocus averaging, rest assured that this is the way things are done.

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[5] Extract from Low Level Radiation Campaign response to DETR consultation on the recycling of contaminated materials arising from Clearance of nuclear sites. This document plus hundreds of pages of instructive information can be found on the website of the Low Level Radiation Campaign at www.llrc.org.

But why? And what's the big deal anyway?

A single example will suffice to reveal the nature of the carny game being exposed. Imagine a soldier on a battlefield maneuvering downwind of a burning tank recently destroyed by a depleted uranium penetrator. Inhaling smoke from the fire, the soldier draws deep into his lungs a single particle of uranium oxide, UO_2.[6] (It's important to keep in mind that this is an ideal example. A victim so exposed to depleted uranium may inhale hundreds of thousands of particles.) The particle is small in diameter, 2.5 microns or 2.5 millionths of a meter, which is equivalent to one ten-thousandth of an inch. (Particles this small are considered respirable. They are capable of reaching the non-ciliated portion of the respiratory airways and can remain lodged in the lung for years or even an entire lifetime.) A depleted uranium particle of this dimension is estimated to consist of 2.10×10^{11} (210,000,000,000) atoms of the uranium isotope U-238. While lodged in the lung, the uranium atoms undergo radioactive decay at a rate determined by that isotope's unique half-life, the time required for one half the atoms in a sample to spontaneously decay by emitting particles and/or energy from their nuclei. Due to the long half-life of uranium, 4.5 billion years, on average only 32.3 atoms making up the particle will decay each year. To complicate the scenario, depleted uranium is not pure uranium-238. Present are atoms of other uranium isotopes with their own unique half-lives and energy emissions: uranium-234, uranium-235, and uranium-236. Together, these three uranium isotopes undergo an additional 5.3 atomic disintegrations per year. So, all tolled, approximately 38 atoms within the particle trapped in the lung of the soldier undergo radioactive decay each year. Taking into account the density of the tissue and the energy of the emitted alpha particles, the alphas will travel no more than a distance of 0.00331 centimeters. If the depleted uranium particle is visualized as residing at the center of a sphere with a radius equal to the maximum distance capable of being traversed by the alphas, the volume of cells potentially affected by the radiation will be 1.519×10^{-7} (0.0000001519) cubic centimeters. When the total energy delivered by the alphas in one year to this microscopic volume is calculated, the dose is **17 rads**. Taking into account the relative biological effectiveness of alpha particles, the dose to the vulnerable population of cells is **170 rem per year**. In the microscopic domain, this is a tremendous amount of energy radiating through a very confined volume.

In discussing the results of this calculation, Leonard Dietz offers the following observation:

> The Code of Federal Regulations dealing with energy specifies per-

[6] The figures presented in this scenario are drawn from an article by Leonard A. Dietz entitled "Estimate of Radiation Dose from a Depleted Uranium Oxide Particle." http://www.xs4all.nl/~stgvisie/VISIE/Dietz-L/Dietz-du-3.html

> missible radiation doses. Occupational doses (for radiation workers) shall not exceed 5 rem/yr., except in unusual circumstances. For the general population, the annual limit is 170 millirem (0.17 rem) and a specific limit of 500 millirem (0.5 rem) for any individual in the general population.
>
> If the above estimate of radiation dose (170 rem/yr.) received by lung tissue surrounding the depleted uranium oxide particle is correct, then it is 34 times the maximum dose that radiation workers are permitted to receive and 100 times higher than the maximum acceptable dose for the general population. For a 5 micrometer diameter depleted uranium oxide particle (8 times the volume), the estimated dose is 1,360 rem, or 272 times the maximum permissible dose to a radiation worker. Until these doses can be related to a cancer risk factor, they must be viewed as qualitative indicators of danger, as red flags.

Quite obviously, the currently accepted model "cannot deal with small volumes and inhomogeneities of dose, and for this reason is unsafe to apply to internal radiation" (ECRR). According to current statutes, a member of the public is permitted in any one year to receive no more than a dose of radiation *to the whole body* of 0.5 rem. It is thought that the organism can absorb the energy of 0.5 rem, and undergo the amount of ionization produced by this energy throughout its molecular structure without causing any significant health detriment. And yet, the single particle of depleted uranium transfers in one year 170 rem to the tiny cluster of cells in its immediate vicinity. This small conglomerate of vulnerable cells is driven into extreme chemical chaos by this single alpha-emitting particle. Until the risk to the hit cells is determined by experimentation, it is scientifically unwarranted to conclude that an inhaled depleted uranium particle is benign. This example highlights an important principle: **It is at the level of the cell where radiation effects become significant, not over large masses of tissue.** An honest approach to radiation safety would be grounded on this fundamental fact.

Busby has performed similar calculations to the one presented above. In his example, a particle with a diameter of 2 microns is lodged in the lymphatic system. As with the previous example, the dose to the cells in the immediate vicinity of the particle is 150 rem (1500 mSv) per year. By comparison, Busby provides a calculation of how the ICRP would calculate the dose ***averaged over the whole lymphatic system*** which is considered to be a mass of 800 grams. By this method of calculation, the yearly dose to the lymphatic system is only a meager 0.0000021 rem (2.1×10^{-7} mSv).

Pause right here. Observe the crafty sleight of hand that is taking place as a card gets sloughed under the table. The International Commission on Radiation Protection is mesmerizing the world into believing the decay of depleted uranium atoms within the body is insignificant. By a system of smoke and mirrors, they take the energy transmitted by a few alpha particles to a small volume of cells and treat is *as if* this energy is distributed through 800 grams of tissue. Totally false to the reality of the situation, their system DILUTES the impact by suggesting that it is spread over a large volume. In calculating dosage by this manner, the biological effects of imbedded uranium particles is made to appear inconsequential. When the phenomenon is viewed in its true light, the dosage is distributed only to those cells that are actually hit by the marauding alpha particles. A whopping dose of radiation is deposited in a small volume creating significant chemical alterations in the affected cells and setting the stage for mutations and the possible induction of a cancer. When government spokesmen proclaim that depleted uranium does not present a radiation hazard, what method of calculating dosage do you think they are relying upon to substantiate their conclusion?

From these examples, a disturbing truth emerges: The calculation of dosages of radiation from internal emitters based on the averaging of energy over large masses of tissue is a scam. It's charlatanism. It's flimflam. It's a racket of juggling numbers to get them to say whatever the juggler wants them to say. By mathematical prestidigitation, biologically hazardous quantities of radiation can be made to appear innocuous. The august scientific bodies around the world are fabricating lies based on models that do not accurately reflect the reality of the phenomenon. They have erected a monumental intellectual edifice designed to quell the concerns of the public while giving reign to the nuclear establishment to scatter with abandon dangerous quantities of radioactivity over the earth.

<u>Exhibit C</u>

Quite obviously, a major problem exists in the way dosages from internal emitters are calculated. But this is only half the picture. So what if the *theoretical* framework is corrupt? Surely, as a fallback, there must exist a body of research to validate the safety of the levels of internal contamination permitted to the public. But herein lies a startling revelation. The studies upon which the risks to health from low doses of internalized alpha and beta emitters are based are primarily studies of *acute doses of* ***external*** *irradiation by x-rays and gamma rays delivered at a high dose rate*!

Now hold it right there! How can this possibly be? The case was previously made that, from a biological point of view, external irradiation and internal contamination are

qualitatively different phenomena. How can standards of safety for internally incorporated radioactive contaminants be based on photons impinging on the body from the outside? *The assumption made so long ago that external and internal radiation produce the same biological effects has never been validated*. Extrapolating from known effects of external irradiation to predict suspected effects from internal emitters is scientifically without merit:

> With regard to internal radiation doses, the committee [European Committee on Radiation Risk] identifies a serious misuse of scientific method in the extension and application of the ICRP external model. Such a process involves deductive reasoning. It falsely uses data from one set of conditions — high-level, acute, external exposure — to model low-level, chronic, internal exposure. The procedure is scientifically bankrupt, and were it not for political consideration, would have been rejected long ago (ECRR).

In our age of purported scientific enlightenment, this is what the 'guardians of humanity' have been doing behind our backs: They have derived risk factors for internal exposure to radioactivity from a number of studies conducted on external exposure. Justification for the validity of this extrapolation is based on the fallacious model of energy transfer and the averaging of dosages over large volumes of tissue. Mankind's safety from internalized radioactivity is based on the erroneous assumption that there is no physiological difference in how energy is delivered to the body. External irradiation and particulate emission from internalized radionuclides are regarded as being identical phenomena in terms of the physiological effects they induce.

To elucidate the source upon which current standards for permissible levels of internal contamination are based, we can turn to "BEIR V", a 1990 publication by the Committee on the Biological Effects of Ionizing Radiation. According to this document, the Committee's risk factors for radiation exposure were derived from the following studies:

I. <u>The Life Span Study of the Japanese Atomic Bomb Survivors.</u>

The National Census conducted in Japan in 1950 identified approximately 284,000 people who had survived the bombings of Hiroshima and Nagasaki. From this population, 91,231 people enrolled in a study to have their health monitored over their lifetime. In addition, 27,000 people who were located a minimum of 10 km from the hypocenters of the explosions were selected for the study to serve as a control population. An elevated incidence of leukemia and solid tumors were observed in the study population. **The data from this study has become the primary source for assessing the risks from exposure to ionizing radiation.**

II. The Study of British Patients Irradiated for Ankylosing Spondylitis.

Ankylosing Spondylitis is a form of rheumatoid arthritis affecting the spine. In Great Britain between 1935 and 1954, patients with this condition were treated with spinal irradiation. This procedure had the unintended side effect of irradiating a large fraction of the body with substantial doses of radiation. Long-term medical follow-up of 14,106 of these patients revealed an elevated incidence of various cancers and leukemias when compared to a control population.

III. Radiation Dose and Leukemia Risk in Patients Treated for Cancer of the Cervix

This study followed the health consequences to 150,000 women who received radiotherapy for treatment of cervical cancer. Approximately 70% were treated with radium implants or external radiotherapy. The administered radiation delivered substantial radiation doses to organs close to the cervix and moderate doses to organs located more distally in the body. Doses to bone marrow — and consequently, rates of leukemia — were higher than those found in an unexposed population. The radiation dose to the active bone marrow was estimated by medical physicists who had access to the original radiotherapy records.

IV. The Canadian Fluoroscopy Series.

This study followed the health of 31,710 Canadian women for fifty years. Between 1930 and 1952, they were examined and treated for tuberculosis with x-ray doses to the chest. As a result, an elevated incidence of breast cancer was observed. The study divided the women into age groups based on when treatment was received and succeeded in establishing a relationship between the rates of cancer and the cumulative dose of x-rays.

V. The Rochester Acute Mastitis Therapy Series.

This study followed the health of 601 women treated with x-rays for acute postpartum mastitis. The incidence rate of breast cancer within this cohort was in excess of the rate found in a number of different control groups. The radiation dose varied from 60 to 1,400 rads.

VI. The Massachusetts Fluoroscopy Studies.

This research followed the health of 1,742 women who received x-ray treatments for tuberculosis. These women received repeated, low-dose exposures over a period of time. Estimated dosage per treatment was 1.5 rads. The accumulated breast dose was approximately 150 rems. Breast cancer rates were elevated in all age groups above the control population.

These six studies all share one thing in common. **They all involve acute, high-**

dose exposure from external radiation sources. Via mathematical modeling of the computational system, the data from these studies was manipulated to derive the risk posed by radionuclides *delivering chronic, low doses of radiation internally with the total energy delivered averaged over large masses of tissue*. This process is what the European Committee on Radiation Risk refers to as "serious misuse of the scientific method."

By far, the most important of the six studies listed above is the Life Span Study (LSS) of the Japanese survivors of the bombing of Hiroshima and Nagasaki. If you open any textbook on radiation safety, what you will find is a statement saying that what is known about the effects of ionizing radiation on populations is largely based on the data from Japan. The results of this study carry tremendous weight in the field of radiation protection. Currently accepted ideas of the risks to health from radiation exposure are based primarily on the results of this study. Consequently, the health of all of mankind is at stake, grounded on the reliability of this one study. Needless to say, the accuracy, validity and reliability of the Life Span Study is open to question.

The country that dropped the atomic bomb is the same country that funds and controls the Life Span Study. In 1950, five years after the bombing of Hiroshima, an excessive incidence of leukemia began appearing in the exposed population. In response, the Government of the United States established the Atomic Bomb Casualty Commission (ABCC) with the mandate of monitoring the health of the surviving population. In 1975, control of the study was passed to the Radiation Effects Research Foundation (RERF) in Japan. Continued funding is divided between the government of Japan and the government of the United States through the National Academy of Sciences under contract with the Department of Energy.

To fully appreciate the controversy that has arisen over the Life Span Study, it is necessary to revisit the horrific events of Hiroshima and its aftermath. At 8:16:02 AM on the morning of August 6, 1945, the "Little Boy" atomic bomb exploded over Hiroshima. At the moment of detonation, a flash of gamma radiation and neutrons showered the target area and irradiated the entire population. In a microsecond, a thermal pulse baked the city and ignited a conflagration, and a pressure wave smashed most structures to smithereens. Exact casualty figures are not known. Perhaps 100,000 people died from combined injuries from the direct effects of the blast: immense quantities of irradiation, burns, and a vast array of trauma injuries. It is estimated that by the end of 1945, total casualties had climbed to 140,000 people. By 1950, the death toll had reached over 200,000. What had once been Hiroshima was left in radioactive ruin. Radiation contaminated the soil and the water. This created an environment where internal contamination became possible for all who entered the area for years afterward. In the immediate after-

math of the bombing, people who had either lived outside the city or who had left the city center prior to the detonation reentered the city looking for family and friends. These people, not exposed to the detonation, subsequently became contaminated by internal emitters. Nevertheless, they were later included in the control group of the Life Span Study representing people who were not exposed to radiation.

This brief portrait provides all the information the reader needs in order to understand the overwhelming number of errors inherent in the atomic bomb survivor study. Never lose sight of the fact that, in the hands of the ICRP, this study provides the foundation for current models of the risks to health from radiation exposure, and via extrapolation, the hazards of low-dose exposure to internally emitting radionuclides. At a meeting of the European Parliament in February 1998, a number of attendees expressed criticism of the ICRP and the Hiroshima data on radiation effects. These were summarized in the first publication of the European Committee on Radiation Risk (ECRR).

1. Professor Alice Stewart faulted the Hiroshima research on the grounds that the study and control groups were not representative of a normal population. Those included in the study were survivors of the stresses of war who had endured an overwhelming atrocity. Between the end of the war and the establishment of the Life Span Study, as many as 100,000 people succumbed as a result of blast injuries, irradiation, conventional illnesses, and internal contamination from fallout and tainted food and water. As a consequence, **the study omits tens of thousands of radiation-induced deaths that took place in the first seven years after the dropping of the bomb**. Thus, any results of the LSS will inevitably underestimate the hazards of radiation exposure. Due to the multiple stressors of the bombing and its aftermath, a natural selection process was set in motion whereby unfit people, the physically and psychologically weak, succumbed and were weeded out of the study population. A "healthy survivor effect" thus biased the study. By the time the Life Span Study got underway, those studied made up an atypical population that could not adequately represent the delayed effects of radiation exposure for the entirety of mankind.

2. Several participants at the meeting of the European Parliament criticized the ICRP for failing to adequately address the subject of internal contamination. The surviving Hiroshima population was modeled on the basis of everyone receiving an instantaneous barrage of gamma and neutron irradiation at the moment of detonation of the bomb. Completely ignored by the study is the fact that the surviving population was exposed to fallout that compounded external radiation from beta and gamma emitters. Further, soil and water were contaminated by radionuclides creating the opportunity for the ongoing accumulation of internal emitters through the diet. As a consequence, dose estimates, upon which the whole study rests, are meaningless. To make matters worse, when those outside

the city during the time of the bombing entered the city to see what had happened and to look for families and friends, they likely received internal contamination. Thus, the "control" population was also contaminated with radioactivity. What effect does this have on the Life Span Study if both the study population and the control population were exposed to radiation? It will make the incidence of cancer among the study population appear much lower than if a valid comparison were made between those exposed and another suitable control population totally unexposed. By basing the study on an inappropriate control population, radiation is made to appear less hazardous than it actually is.

3. Dr. Chris Busby argued, as has been revealed previously in this chapter, that the model used by the ICRP to model the physiological impact of high levels of external radiation is totally inappropriate for accurately predicting the effects of internal contamination delivered in low doses at a low dose rate. And yet, this is exactly how the Japanese data is used to estimate health risks and derive permissible levels of exposure from internal emitters. According to Busby, by relying on faulty models to assess the risk of internal emitters, the ICRP has failed to accurately determine the true hazards of internal contamination.

4. Dr. David Sumner criticized the ICRP for utilizing the Sievert (equivalent to 100 rem) as a unit of measure. According to his argument, the quality factors introduced into equations to account for differences in the physiological impact of different types of radiation are value judgments and not physical units. To say, for instance, that alpha radiation produces ten times as much biological effect as electromagnetic radiation is not sufficiently rigorous to be used to evaluate the risk from different types of exposure.

5. Dr. Rosalie Bertell challenged the very legitimacy of the ICRP to represent before all mankind the hazards to health of ionizing radiation. "The ICRP is profoundly undemocratic and unprofessionally constituted. It is self-appointed and self-perpetuated" (Bertell, February 1998). Since its inception with some original members drawn from the Manhattan Project, the ICRP has been filled with people who are biased in favor of the nuclear establishment. "ICRP is organized by its By-Laws to include only users and national regulators (usually coming from the ranks of users) of radiation" (Bertell, February 1998). Membership has remained balanced between 50% physicists and 50% medical doctors. About 25% of the doctors have been medical administrators in countries possessing nuclear weapons who set radiation protection standards in their respective countries and another 15% have been radiologists. The remaining 10% of doctors has consisted of one pathologist, two geneticists, and a biophysicist. Women have been completely excluded. The rules of the main committee responsible for making decisions explicitly exclude participation of an epidemiologist, occupational health specialist, public health specialist, oncologist or pediatrician. According to their own mandate, the job of the ICRP is not to protect workers

or public health. Rather, their self-appointed purpose is solely to make recommendations as to what represents a sensible — i.e., "permissible" — tradeoff between the benefits and risks to society of pursuing technologies that result in people receiving exposure to ionizing radiation. Thus, the standards set by the ICRP for what constitutes acceptable exposure are infused with value judgments made by a select few with ties to nuclear weapons and other nuclear technologies.

> In terms of its own claims, ICRP does not offer recommendations of exposure limits based on worker and public health criteria. Rather, it offers its own risk/benefit tradeoff suggestion, containing value judgments with respect to the "acceptability" of risk estimates, and decisions as to what is "acceptable" to the individual and to society, for what it sees as the "benefits" of the activities. Since the thirteen members of the Main Committee of ICRP, the decision makers, are either users of ionizing radiation in their employment, or are government regulators, primarily from countries with nuclear weapon programs, the vested interests are clear. In the entire history of the radiologist association formed in 1928, and ICRP, formed when the physicists were added in 1952, this organization has never taken a public stand on behalf of the public health. It never even protested atmospheric nuclear weapon testing, the deliberate exposure of atomic soldiers, the lack of ventilation in uranium mines, or unnecessary uses of medical X-ray.
>
> The ICRP assumes no responsibility for the consequences attributable to a country following its recommendations. They stress that the Regulations are made and adopted by each National Regulatory Agency, and it merely recommends. However, on the National level, governments say they cannot afford to do the research to set radiation regulations, therefore they accept the ICRP recommendations. In the real world, this makes no one responsible for the deaths and disabilities caused! (Bertell, February 1998).

In reference to the Hiroshima research, Dr. Bertell made similar observations as the other presenters to the European Parliament:

> It [the LSS] has focused on cancer deaths, is uncorrected for healthy survivor effect, and is not inclusive of all of the radiation exposures of cases and controls (dose calculations omit fallout, residual ground radiation, contamination of the food and water, and individual medical X-ray), and fails to include all relevant biological mechanisms and

> endpoints of concern.
>
> It is normally claimed that the biological basis of the cancer death risk estimates used by ICRP is the atomic bomb studies. However, these studies are not studies of radiation health effects, but of the effects of an atomic bomb. For example, the radiation dose received by the Hiroshima and Nagasaki survivors from fallout, contamination of food, water and air, has never even been calculated. Only the initial bomb blast, modified by personal shielding, is included in the US Oak Ridge National Laboratory assigned "dose." This methodology is carried to an extreme. For example, one survivor I know lived within the three kilometer radius of the hypocenter, but was just beyond the three kilometer zone, at work, when the bomb dropped. As soon as she could, she returned home after the bombing and found her parents and brother dead. Then she stayed in her family home for the three following days, not knowing where to go and filled with grief. Although she suffered radiation sickness and many subsequent forms of ill health, she is counted as an "unexposed control" in the atomic bomb data base. By using the "not in the city" population which entered after the bombing as "controls", many of the cancers attributable to the radiation exposure in both cases and controls are eliminated from the outcomes considered related to the bomb (Bertell, February 1998).

Testifying before the United States Senate Committee on Veterans' Affairs in 1998, Dr. Bertell dropped a bombshell. The team that had assigned dosages in 1986 to Japanese survivors assigned a dose of ZERO to anyone with a calculated dose less than 10 mGy (1 rad). This represented a total of 34,043 participants in the study: 37.3 percent. These people, purely by definition, were assigned to the "not exposed" control group. This decision effectively destroyed the possibility of any detection of heightened incidences of illnesses from those who actually received low-level exposure. Further, by lumping those exposed into the unexposed control group, the LSS is weighted to underestimate the health effects of radiation due to an unsuitable control population. These irreparable errors invalidate any possible conclusions of the LSS as they pertain to low-level exposure. Radiation protection standards are grounded on the research from Japan. What is thought to be the effects of low doses of radiation are extrapolated mathematically from the observed high dose effects discovered by the Life Span Study. As a result of Dr. Bertell's revelation, however, it is clear that the *Atomic Bomb research can have no relevance to any discussion about the health effects of low doses of radiation*. Those who supposedly received low doses had their exposure nullified. If honesty prevailed, this fact alone would shake the radiation protection community. A cornerstone of current approaches to radiation safety holds that the hazards posed

by low doses of radiation can be inferred from the effects observed in Japan from high doses.

> The atomic bomb researchers assumed (but did not demonstrate or prove) that below 1 rem exposure from the original bomb blast no radiation related cancer deaths would occur. Therefore this data base can tell us nothing about such low-dose exposures because the researchers assumed their exposure was "safe" and did not test for an effect. In philosophy, we call this "begging the question" and it results in an invalid "proof" (Bertell, April 1998).

There is other evidence available in the public domain that seriously questions the structure of the Life Span Study in regards to the assignment of dosages received by Japanese survivors:

> Detection of radiation risks depends upon the ability of an epidemiological study to classify persons according to their exposure levels. A-bomb survivors were not wearing radiation badges, therefore their exposures had to be estimated by asking survivors about their locations and shielding at the time of detonation. In addition to the typical types of recall bias that occur in surveys, stigmatization of survivors made some reluctant to admit their proximity [Lindee]. Acute radiation injuries such as hair loss and burns among survivors who reported they were at great distances from the blasts [Nerishi 1991, Nerishi 1995] suggests the magnitude of these errors, which would lead to underestimation of radiation risks (Wing).

In his book *Wolves of Water*, Chris Busby recounts information gathered by Kate Dewes who visited Hiroshima and Nagasaki in 2001 and interviewed a number of female *Hibakushas*, the "explosion-affected people." As a woman relating to other women, Dewes gained firsthand knowledge of significant flaws in the Life Span Study. In Japan, the *Hibakushas* are stigmatized. As a consequence, many carry with them feelings of shame. Further, many attempt to hide their experience, or if second generation, the experience of their parents, for fear that association with the bombing will interfere with their opportunity for employment, marriage, and having children. These obstacles to forthright communication are compounded by the fact that as women, they are reticent to speak with male researchers or doctors on "sensitive issues" regarding their health. With this said, a number of women reported to Dewes that they knew of women who had given birth to deformed and intellectually handicapped children who then hid them away so as not to be discovered. More importantly, women reported that researchers frequently did not inquire about their menstruation, fertility, history of miscarriages, and birth outcomes. These rev-

elations are astounding. To an unknown degree, the data from Japan is incomplete. Radiation effects occurred which were hidden from researchers. This would have skewed the results of the Life Span Study toward underestimating the true risks from radiation exposure.

While in Japan, Dewes became privy to other information regarding gross birth abnormalities. These effects are absent from the Life Span Study. **According to the Atomic Bomb Casualty Commission, there was no increase in the incidence of birth defects among children whose parents were exposed to the blasts (Nakamura).** Dewes reports differently:

> After the bombings, midwives in Hiroshima and Nagasaki became very concerned about the number of deformed babies being born. In the September 1954 issue of *Health and Midwifery*, it was reported that about 30,150 births were observed in Nagasaki from 1 January 1950 to 31 December 1953:
>
> "Before the bomb was dropped the proportion of abnormal children to those born healthy was very low, but in the nine years since the bomb was dropped this proportion has changed enormously. Of 30,150 babies born, 471 were stillborn and 181 were abortions. Of those born alive, 3,630 were abnormal and the abnormality was divided as follows:
>
> * 1046 children suffered from degeneration of the bone, muscle, skin or nervous system
> * 429 from deformation of organs of smell and hearing
> * 254 from malformation of lip and tongue
> * 59 had a cleft palate
> * 243 suffered from malformation of the inner organs
> * 47 from deformation of the brain
> * 25 children were born without a brain
> * 8 without eyes and sockets of the eyes.

While traveling with women who were visiting Japan from the Marshall Islands, Dewes heard stories of women who, after being exposed to fallout from the Bravo nuclear test in 1954, gave birth to "jellyfish babies" and "bunches of purple grapes." During her travels, Dewes heard stories of identical types of birth outcomes experienced by the *Hibakushas*. For those who have the stomach for it, images of these hideously deformed types of babies, if that's the right word for them, can be found on the internet, born to women in Iraq after that country was contaminated with depleted uranium.

An interesting historical fact is worth interjecting at this point which gives some perspective on the political forces at work behind the Hiroshima Life Span Study. Many of the Japanese researchers conducting the study were pardoned war criminals who did research in biological warfare and conducted hideous experiments on captured Chinese in Manchuria. They were granted immunity by the US Army in exchange for the results of their experiments. Rosalie Bertell has briefly recounted this history (Bertell, February 1998):

> Interestingly, the Atomic Bomb Casualty Commission (ABCC) and its successor organization, the Radiation Effects Research Foundation (RERF), has, since the beginning, collaborated with the Japanese National Institute of Health (JNIH). ABCC was set up by the occupying force in September 1945. Their Japanese partner was responsible for hiring and firing all Japanese scientists who worked on the A-bomb data, although the US assumed singular control of all of the dose assignments once they were available.
>
> The JNIH was actually established by the order of the US Forces (Lindee), staffed with scientists from the Institute of Infectious Disease (IID) attached to the University of Tokyo, and containing most of the leading medical scientists from the Japanese Biological Warfare (BW) Institutions and the infamous Unit 731, which was responsible for the gross experimentations with humans in Manchuria during World War II (Williams and Wallace). The Japanese scientists who engaged in biological warfare experiments on live human beings, allegedly including allied prisoners of war, were granted immunity by the US Army from investigation for war crimes in return for the results of their experiments.
>
> Kobayashi Rokuzo, advisor to the IID laboratory was attached to the Japanese Army's Medical College headquarters of the BW network, was Director of JNIH from 5/47 to 3/55. His Vice-Director for the same term was Kojima Saburo, who had intensively cooperated with BW Unit 1644 in the vivisection of humans at Nanking, and with the IID unit during the occupation of China. The Director of the JNIH from 3/55 to 4/58 was Komiya Yoshitaka, who was a member of the Institute of Health in Central China during the occupation, part of the BW network of hospitals run by the Military Police. Yanagisawa Ken, Vice-Director from 10/58 to 3/70, conducted experiments on Chinese youths during the occupation, through BW Unit 731. It was through these human experiments that he developed dried BCG,

> becoming "eminent" in medical circles. The list is much longer, including Directors and Vice-Directors up until 1990, scientists known to have conducted military experiments on humans (Shingo).

Returning to the subject at hand, the European Committee on Radiation Risk has compiled its own list as to why the Hiroshima research is totally incapable of providing relevant information on the effects of low levels of internal contamination:

1. The Hiroshima study includes an inappropriate control population. Both the study group and controls were internally contaminated.

2. Mathematical extrapolation from high doses to low doses fails to account for known cellular processes. The ECRR is highly critical of the methodology of mathematically deriving risks to health created by low doses of radiation from data on high doses. According to their rationale, this process fails to address well-established biological phenomena that have been observed at low doses. To offer just one example here (others will be offered in Exhibit D), at high doses there is a greater likelihood of cell killing among targeted cells while at low doses delivered at a low rate, which occurs from internalized radioactivity, there is a greater likelihood that cells injured by radiation will survive but in a mutated form. As a consequence, cancer incidence from internal exposure to low levels of radiation would be greater than that predicted from a simple linear extrapolation from acute dosages of external radiation.

3. In making extrapolations from an acute one-time exposure, as in the case of Hiroshima, to chronic repetitive low-dose exposures that occur from particles of internally embedded radionuclides undergoing radioactive decay, the ICRP model fails to address the fact that a variation in cell sensitivity is introduced into a cell population after initial exposure. Cells once exposed to radiation exhibit increased sensitivity to alteration following subsequent exposure.

4. The ECRR mentions another major flaw in extrapolating from external to internal exposure. When the bomb detonated over Hiroshima, an enormous barrage of photons was ejected in all directions. Those photons passing through human bodies delivered a homogeneous, whole-body dose of radiation to each victim. While traversing through body cells, each photon followed a single track, creating molecular disruption along its path until its energy was expended. Photons are said to have low LET, linear energy transfer. Along their path, they transfer, "on average," less energy per micrometer than alpha or beta particles. This has the effect of creating a sparse pattern of ionization through a cell, i.e., ionizing events are spaced further apart along a track compared to the more dense patterns

of ionization created by alphas and betas. Consequently, the photons released from the bomb possessed a relatively low probability of multiple tracks intersecting at the same critical structures within the same cell, i.e., the DNA molecules. In contrast, radionuclides within the body's interior represent a different phenomenon. Cells in close proximity to embedded particles are vulnerable to being repeatedly hit by the tracks of alpha and beta particles ejected during radioactive decay. Further, these particles have high LET. They create a denser pattern of molecular disruption within a cell. Depending on the radionuclide involved, the nuclei of neighboring cells are more likely to be hit by multiple tracks created during critical times in the cell's life cycle either as a result of multiple hits from atoms of the same radionuclide or from sequential decays of the same atom. As a consequence, internal emitters are more likely to create multiple tracks through the same cell's nucleus and create more molecular damage in and about the DNA. For this reason, internal radiation will have a much greater chance of altering cell function and inducing mutation than that caused by external radiation. Under this scenario, low doses from internal emitters are vastly more hazardous to cellular well-being than higher doses delivered to cells externally.

5. Currently, the ICRP embraces the model in which biological damage is directly proportional to dosage. Once again this assumption is based on extrapolation from high doses. This is what is called the Linear No-Threshold Hypothesis. Based on the biological response of cells to low doses of radiation, the ECRR holds that this assumption is "patently not true."

6. The ECRR maintains that the Life Span Study is not representative of other populations of people all over the world. It is an incorrect extrapolation to assume that the findings from Hiroshima are equally valid for all human beings since research has established that different populations manifest different levels of susceptibility to radiation injury.

7. The ECRR also faults the Hiroshima study because the study group is made up of war survivors. This, once again, is an expression of the healthy survivor effect. The Japanese survivors were selected by the pressures of war and the bombing due to their increased resistance, and thus, cannot be suitably compared to populations that have not endured similar stresses.

8. The Life Span Study has built-in inaccuracies due to the fact that it was started too late and missed many of the early deaths caused by radiation. This has had the effect of skewing the statistics to making radiation appear less hazardous than it in fact actually is.

9. The Life Span Study confines itself to the study of radiation-induced "fatal" can-

cers. Confining itself to this focus, the total health detriment induced in the surviving population is completely ignored. Once again, this misrepresents the true impact of ionizing radiation on human health. In addition to fatal cancers, inheritable damage, and IQ retardation which is considered by the ICRP and other risk agencies, the ECRR advocates inclusion of other health effects including nonfatal cancers, benign neoplasms, infant mortality, birthrate reduction, and low birthweights. General reduction in the quality of life and nonspecific life shortening are further consequences that must be included when evaluating the health effects of radiation exposure.

10. Genetic damage created by the bombing in Japan is modeled on gross abnormalities manifested in births of subsequent generations. The study overlooks more subtle genetic effects that nevertheless may have profound impact on the health of progeny over time.

As if these criticisms were not enough to convince anyone that the results of the Life Span Study are seriously corrupted, two further objections have been raised. One is mentioned by Busby in *Wings of Death*. He observed a large discrepancy between the cancer statistics published by the Atomic Bomb Casualty Commission for the period 1957-8 and those released by the Hiroshima Cancer Registry. According to the ABCC, the incidence of non-leukemia cancers among those survivors who were located within 1,500 meters of the hypocenter of the atomic bomb detonations was 338. In contrast, the Hiroshima Cancer Registry, for the twenty-month period between May of 1957 and December of 1958, reported that the same population had developed 1502 non-leukemia cancers. Adjusting this data for a twelve month period to offer a basis of comparison, Busby derived a figure of 90 non-leukemia cancers. When the incidence of these cancers was compared to the control population, the results were striking:

> Comparison of these two sets of results for the same population, for the same period makes for a curious sense of having fallen through the looking-glass. This feeling is one which is often experienced when attempting to follow published reports relating to the health effects of radiation. The Hiroshima Cancer Registry shows a 400 per cent increase in non-leukemia for the highly exposed group; the ABCC finds only a 30 per cent increase in the highly exposed group. It was the ABCC figures that were used as the basis of risk assessment: no one has ever explained the discrepancy.

An even more disturbing problem with the A-Bomb study has been unveiled by John Gofman in his book *Radiation-Induced Cancer from Low-Dose Exposure: An Independent Analysis, 1990*. In the fifth chapter of this book, Gofman provides a detailed history of the Life Span

Study. Wading through technical minutia to explain the study's structure and how it has been managed over the years, Gofman reveals highly disturbing practices in the conduct of the study that may have well destroyed the usefulness of the study for providing "objective" information about the effects of ionizing radiation on human health. What has taken place is major manipulation of the data in ways contrary to the standard and acceptable practices for conducting epidemiological studies.

Gofman relates four fundamental rules followed by epidemiologists all over the world to prevent bias from contaminating and ruining their studies.

Rule One: Once a study begins, the original input cannot be altered. The importance of this rule is to ensure that, as the outcome of a study becomes known, those who might not be pleased with the findings cannot change the original input to produce a more desirable result.

Rule Two: To further ensure that no bias creeps into an epidemiological study, those investigators in a position to ignore rule one and alter the original input should not have access to the results of the study as these begin to accumulate. Only those who are blind to the outcome are in a position to fairly alter the input once it has been established.

Rule Three: If retroactive alteration of the input is required part-way through a study, the credibility of results can only be safeguarded if investigators meticulously justify the scientific need for any changes and prove unequivocally that bias has not been introduced into the final results.

Rule Four: The original cohorts of a study must be kept intact. Continuity of the original structure of a study is the strongest defense against the insinuation of bias into a study's outcome. Shuffling people from one cohort to another as the results of the study begin to be tallied totally destroys the study's integrity and credibility and invites doubts as to the accuracy of the results.

While reviewing the chronology of the A-Bomb Study and the changes introduced to it over time, Gofman evidences major violations of these rules. One disturbing trend throughout the course of the study has been a continual shifting of the input by changing the make-up of the study population. At one time, thousands of new survivors were added to the study population. At another time, thousands of others were suspended. As Gofman comments:

> It seems as if RERF has been conducting one public study, with 80,000 survivors on view, plus another study with over 34,000 addi-

> tional A-bomb survivors in reserve, who are followed-up and selectively added to the public study as needed.

Simultaneously there has been an ongoing process of reassigning dosages of radiation received by each survivor. The revision in dose estimates have ostensibly been introduced for the purpose of improving accuracy to the study. Unfortunately, those involved in this process have not been blind to the emerging incidence rates of leukemias and cancers and to the make-up of the shifting cohorts.

The Life Span Study is plagued by ongoing, fatal problems. As time passes and the population of Japanese bomb survivors ages and dies, the incidence of cancers is being recorded. While this is occurring, an ongoing process of retroactive altering of the study is being undertaken, changing the make-up of the study population and the dosages these people received. This is a high stakes game. The conclusions of this study will be referred to for generations as the definitive study of the relationship between ionizing radiation and cancer hazard. Mankind's trust in the safety of nuclear enterprises way into the future will be heavily influenced by the outcome of this single study. Unfortunately, those who uphold disinterested science as the final arbitrator in the quest for truth will be hard pressed to believe that bias has not hopelessly infected the A-Bomb Study to produce a predetermined outcome which makes radiation appear less hazardous than it actually is.

It does not take an epidemiologist to recognize that the Life Span Study is hopelessly flawed and unable to provide any definitive conclusion on radiation effects to the human body. Yet, it continues to serve as the foundation for regulatory agencies with regard to what constitutes permissible levels of exposure to ionizing radiation. Why? By this time, the answer should be obvious. It fulfills a political agenda. It is an instrument of an intentionally crafted disinformation campaign designed to keep the public unaware of the long-term health effects of nuclear weapons, nuclear power plants, radioactive waste, depleted uranium munitions, and so on. That the worldwide radiation "protection" community adheres to the validity of this plagued study is self-damning, raising legitimate questions about the impartiality and objectivity of its members. With so many "authoritative" bodies upholding this deeply flawed scientific work as the ultimate revealer of truth about radiation effects, the public is condemned to be submerged in lies, herded in ignorance, and deterred from formulating informed opinions about the genuine health effects of nuclear and radiological weapon programs. Think to the political ramifications of the corrupted Hiroshima data. It's all about people who ***survived*** a nuclear weapon. It is fabricated so as to offer testimony that the survivors of Hiroshima and Nagasaki were not subjected to undue suffering or catastrophic health consequences as a result of exposure to ionizing radiation. If these people emerged unscathed by radiation, what basis does anyone have to

complain about emissions from nuclear power plants or depleted uranium scattered over people's homelands? Further, the A-Bomb Study, focusing on fatal cancers to the exclusion of all other health effects, makes the aftermath of atomic warfare appear relatively benign. With high rates of cancer already in existence, what's the big deal if cancer rates creep imperceptibly higher? The mentality that sponsors and endorses the Life Span Study is the same mentality that advocates that nuclear war is winnable, tactical nuclear weapons are useable, and radiological weapons have a place on today's battlefield. This dogma is dangerous, a product of corrupted thinking perpetrated by the Cult of Nuclearists, that may very well draw the entire world over the edge into limited or total thermonuclear war.

Exhibit D

The astute reader may have asked at some point why the history of radiation safety provided earlier in this chapter stopped where it did in the 1950s following publication by the ICRP and NCRP of the first standards of safety for internal contamination. What happened to the second half of the Twentieth Century? This is the million-dollar question. The model used today by international agencies formulating safety for internal contamination by radionuclides is essentially the same model, with updated modifications, developed during the Manhattan Project, the Tri-Partite Conferences, and the meetings of the committees on internal emitters of the NCRP and the ICRP. **This model was developed prior to the discovery of DNA!** Since the 1950s, a revolution has taken place in biology. Entire vistas of cellular and molecular biology, totally unsuspected by World War II physicists, have opened up for scientific exploration. The rapid advancement in technology has created powerful tools for imaging cellular structures and probing the mysteries of the molecular chemistry that orchestrates cellular processes. Advances have been so profound that, today, microbeams can deliver individual alpha particles to cells *in vitro* and the altered morphology of cellular structures can be determined by DNA sequencing and correlated with functional aberrations. Over this amazing new world of microscopic wonders and the deepening understanding of the cellular and molecular basis of life, the ICRP, NCRP, NRPB, UNSCEAR, and BEIR, like Fascist dictators, inflexibly demand that their archaic model of radiation effects be the basis for radiation protection. They tyrannize all discussions on the biological effects of ionizing radiation, and are rigidly intolerant of allowing other points of view from gaining a footing. Despite the fact that cellular response to radiation can now be studied as never before, these "august" bodies of self-declared experts insist that radiation effects can only be properly modeled as they were modeled in the early 1950s. This state of affairs is despotic. The ruling paradigm on radiation effects maintains its supremacy by ignoring a half-century of research in the biological sciences.

A review of a half-century of radiation biology is beyond the purview of this book. The purpose of Exhibit D is to introduce to the reader a small number of fascinating, well-established, scientific facts pertaining to how cells respond to ionizing radiation. What is significant is that these phenomena cannot be adequately taken into account by the current methods used by the radiation protection agencies for determining the health risks from internal, low-level radiation exposure. Their models cannot accommodate these facts. Exhibit E will then offer an explanation for why an antiquated system of radiation safety is being propped up in defiance of advancing knowledge.

According to conventional wisdom, when the DNA of a cell's nucleus is "hit" by radiation, one of three outcomes is possible: (1) The DNA lesion is readily repaired and the cell emerges from the event unharmed. (2) The damage is of such a nature that it brings about death to the cell. (3) The cell survives in an altered form with radiation-induced mutation(s) to its DNA which are subsequently passed on to daughter cells during cell replication. These inheritable mutations may produce alteration in function within the cell. These in turn may instigate a cancer. It was not until the 1990s that a number of studies confirmed that a fourth avenue was possible for cells hit by radiation. At the moment of exposure, instability to the genome of a cell can be introduced which is not immediately apparent. The cell emerges from the event seemingly unscathed. No detectable aberrations are observable. Only with the passage of time, after a number of generations of cell division, does an instability begin to manifest itself as "abnormally high rates (possibly accelerating rates) of genetic change occurring serially and spontaneously in cell-populations, as they descend from the same ancestral cell [originally hit by the radiation]" (Gofman 1998). What is of interest is that the descendant cells that begin to manifest genetic abnormalities are not the original cells that received the radiation exposure. Moreover, after the first manifestation of chromosomal aberrations, continued cell division introduces yet further aberrations and DNA lesions which have no apparent relationship to the aberrations appearing first. The tentative conclusion at this point is that the initial radiation exposure damages the whole genome of the cell in such a way as to render it incapable of maintaining its stability over time.

Within the nucleus of each of the approximately ten trillion cells in the body of a human being, an exact copy of that individual's genetic code can be found. The integrity of this operating system is maintained by the ordered sequence of nucleotides along the length of the DNA molecules. DNA is not inherently stable. Agents from both within and outside the cell can induce changes to its structure. To counter these influences and ensure stability to the genome, an elaborate molecular system continually monitors the accuracy of the sequencing along the DNA and repairs any deviations. As a consequence, when a cell undergoes division, each progeny cell contains a faithful reproduction of the genetic

sequences present in the parent cell.

Exposure to radiation can adversely affect this system of stabilization of the genome. This can be induced by even the removal of a single nucleotide in the DNA sequence.

> The nature of the genetic code is such that mutations need not be gross in order to have gross biological consequences. For instance, permanent removal of a single nucleotide (a micro-deletion) can totally garble much of a gene's code, by causing what is called a "frame-shift." Then this nonfunctional gene can be the phenomenon which wrecks part of the system which would otherwise maintain genetic stability.
>
> In the mass media, some writers have expressed astonishment that radiation-induced genomic instability is not detected until several cell-divisions have occurred after the radiation exposure. They seem to imagine that the delay reflects a mysterious discontinuity between cause and effect. There is no discontinuity, of course. With current techniques, and with uncertainties about where to search closely among a billion nucleotides, it is just not possible to detect every intermediate step.
>
> The induction of genomic instability in a cell does not guarantee that it will become malignant. Genomic instability increases the rate of mutation in that cell and its descendants, and with this higher rate, the cells each have a higher probability that at least one of them will accumulate all the genetic powers of a killer-cancer. These powers include the ability to thrive better than normal cells, to invade inappropriate tissue, to adapt to the new conditions there, to recruit a blood supply, to fool the immune system, and many other properties (Gofman 1998).

The exact mechanism responsible for the initiation of genomic instability has yet to be identified. Perhaps more than one mechanism exists. Or, perhaps a chorus of combined mechanisms needs to be activated to induce the phenomenon. To date, no identifiable single lesion in a gene or chromosome has been identified as the trigger for genomic instability. A more pervasive intrusion on the cell's regulatory functions is hypothesized. A possible explanation is that a radiation-induced interference disrupts the system governing DNA repair, the system responsible for the accurate duplication and distribution of DNA to progeny cells, or the system that regulates gene expression. Further, it may be the case that some individuals carry a genetic predisposition to these destabilizing influences. If such variation

exists in human beings, standards of radiation safety presumed to be applicable to *all* human beings may be very shortsighted. It is important to note in passing that observations of mammals has confirmed that genomic instability can be induced in germ cells and be passed on to the genome of developing offspring. Thus, it is plausible that inherited genomic instability plays a part in the initiation of developmental abnormalities, stillbirths, birth defects, and infant mortality. In light of this, the finding that depleted uranium has been found in the semen of Gulf War veterans, when added to the accumulating anecdotal evidence of an increased frequency of birth defects in the population of Iraq, makes the indiscriminate scattering of depleted uranium in the environment truly alarming.

One of the landmark studies on genomic instability was published in 1992 by Eric Wright, Munira Kadhim, and colleagues (Kadhim *et al.*). In the course of their research, they exposed stem cells from the bone marrow of mice to plutonium-238, giving them a dose of from 0 to 5 grays of alpha radiation.

> The cells were kept in Petri dishes for 11 days until they had divided between 10 and 13 times, each producing between 10,000 and 100,000 daughter cells. Wright found that the progeny of the irradiated cells contained three and a half times as many chromosome aberrations as the descendants of cells that were not irradiated. In a letter to *Nature*, he concluded that **the "relative biological effectiveness" — a measure of how damaging low-level radiation can be in the body — for isotopes that emit alpha particles is "effectively infinite"** [emphasis added] (Edwards).

In the fall of 1995, more than thirty radiation biologists and health specialists attended a workshop in Helsinki to discuss the health consequences to the public of radiation-induced genomic instability. When compiling the available published information on genomic instability, attendees cited twenty-six studies that suggested that the "accepted rules for calculating the biological impact of radiation should be rewritten" (Edwards). According to Jack Little, professor of radiobiology at the Harvard School of Public Health and an attendee of the workshop: "Genomic instability changes our way of thinking about how radiation damages cells and produces mutations." After the workshop, participants prepared a report for the World Health Organization. This report was never published. However, the magazine *New Scientist* acquired a copy and published excerpts. Included in the report was the observation that genomic instability is a key event not only in the process leading to cancer but to the development of other diseases as well. This insight is revolutionary. If confirmed, it will effectively destroy current concepts of radiation safety.

> Instability is also a "plausible mechanism" for explaining illnesses

> other than cancer, the report says. "It would seem likely that if genomic instability led to health effects these would not be specific but may include developmental deficiencies in the fetus, cancer, hereditary disease, accelerated aging and such nonspecific effects as loss of immune competence." Epidemiology would be "powerless" to detect any relationship between the incidence of such diseases and exposure to radiation, the report says, because the number of people who would suffer any single disease would be too low. [Keith] Baverstock, who was the main organizer of the Helsinki workshop, and Wright believe that the world should be more wary of low-level radiation. If genomic instability is causing unpredicted disease, and if some people are genetically predisposed to it, the regulatory system starts to look inadequate. Existing measures meant to protect people, argue Wright and Baverstock, are less than reassuring (New Scientist).

In response to these observations, people who support the reigning ICRP paradigm will argue that any illness induced by genomic instability will already be accounted for within existing safety limits. This position is untenable. It is based on the unfounded assumption that the frequency of *all* possible endpoints of radiation damage (not just cancer) are linearly related to dose and valid extrapolations about low internal doses of radiation can be made from high doses of radiation delivered exterior to the body. According to the model of radiation effects upheld by the nuclear establishment, cancer is the fundamental endpoint of concern following radiation exposure. Further, the frequency of cancer expressed in a population after exposure is directly related to the dose of radiation received by that population. In sharp contrast, as illustrated in the quotation above, radiation-induced genomic instability may produce "developmental deficiencies in the fetus, cancer, hereditary disease, accelerated aging and such nonspecific effects as loss of immune competence." This hypothesis is revolutionary and in direct conflict with mainstream adherence to the belief that radiation damage to the human organism is confined to cancer. If this proves to be the case, it is totally without justification at this point in time to assume that these results are similarly in a linear relationship to dose and that current standards of safety protect the population from these endpoints. As has already been discussed, dosage is too imprecise a concept to account for radiation-induced changes on the cellular level from low levels of radiation. The number and rate of charged particles passing through the cell is a more fundamental phenomenon. This shift of perspective is essential for explaining newly discovered cellular effects of radiation.

The subject of depleted uranium will be explored in depth in subsequent chapters. But one observation is relevant at this point. Within the currently accepted framework for understanding radiation effects, battlefield dispersal of depleted uranium cannot possibly

pose a radiological hazard. The "dose" of radiation is just too small. But in the light of current research, this point of view is no longer defensible. Two *in vitro* studies were recently conducted involving exposure of human osteoblast cells to depleted uranium. Both studies demonstrated that depleted uranium induces genomic instability in the progeny of cells receiving exposure. One study exposed cells to uranyl nitrate created from various isotopes of uranium and compared their toxic effects to cells exposed to the heavy metals nickel and tungsten (Miller *et al.*, 2002). Those cells exposed to DU evidenced an increased frequency of dicentric chromosomes — chromosomes with two centromeres — when compared to the nonradioactive metals. Further, the frequency of dicentric abnormalities was dependent on the specific radioactivity of the different isotopes. The conclusion was that it was alpha radiation emitted by uranium that induced the chromosomal aberrations. According to Miller and her colleagues, "Published data from our laboratory have demonstrated that DU exposure in vitro to immortalized human osteoblast cells (HOS) is both neoplastically transforming and genotoxic." A second study conducted by the same research team exposed osteoblast cells to gamma radiation and alpha radiation from depleted uranium and compared the effects to nickel exposure (Miller *et al.*, 2003). Cell lethality and micronuclei formation were measured at various times after exposure. (Micronuclei arise from DNA double-strand breaks that are not rejoined. These have been implicated in carcinogenesis.) It was found that DU stimulates delayed reproductive death and the production of micronuclei up to thirty-six days (thirty population doublings) after exposure. This is evidence of induced destabilization in the genome. In contrast, the cell populations exposed to gamma radiation returned to normal after a period of twelve days. Further, micronuclei formation from DU exposure occurred at a greater frequency than for equal doses delivered by gamma irradiation. The authors summarized their results as follows: "These studies demonstrate that DU exposure results in genomic instability manifested as delayed reproductive death and micronuclei formation." Together these two studies demonstrate that the alpha radiation emitted from depleted uranium can damage DNA and that DU can induce instability to the genome that initiates abnormal growth in progeny cells. Only in political defiance of these observed phenomenon can propagandists continue to affirm that depleted uranium poses no radiological hazard.

In the cold, mechanistic, clockwork universe of the physical scientist, the phenomena of love, compassion and empathy are driven into exile. There is no mechanism that can account for these experiences. When I am hit, I suffer alone. You standing beside me remain untouched by my misery. This state of affairs, however, is not true to the human experience. In the world of relatedness and relationship, when I am hit, you beside me bleed. Reclaiming mechanistic science from out-of-touch abstraction is biology, the study of life. This is the metaphorical significance of the recently discovered "bystander effect," a second intriguing biological phenomenon that calls into question current assessments of

risk from exposure to low doses of radiation.

Up until the closing years of the twentieth century, research in radiation biology was guided by the foundational assumption that radiation-induced damage to cells was a *direct consequence* of the transfer of energy to cellular molecular structures, DNA being the primary target. Those cells "hit" by radiation were damaged at the instant of exposure or shortly thereafter, and the consequences were expressed within one or two cell generations. Those cells not hit by radiation escaped damage altogether. Within the physicist's paradigm, there was no mechanism by which non-targeted cells could receive injury from radiation. Discovery of the bystander effect dashed this shortsighted, unfounded assumption. In the realm of the living, cells hit by radiation communicate the assault to cells in their immediate vicinity, and the non-targeted cells respond by undergoing similar destructive transformations as if they had actually received the blow themselves.

The 'bystander effect' is the name given to a cell-to-cell communication process by which the damage created in cells hit by radiation is communicated to non-hit cells. These cells in turn manifest damage — often very extensive damage — similar in kind to that received by the targeted cells. "The radiation-induced bystander effect is a phenomenon whereby cellular damage (sister chromatid exchanges, chromosome aberrations, micronucleation, transformation, gene expression) is expressed in unirradiated neighboring cells near to an irradiated cell or cells" (Belyakov *et al.*). Besides immediately observable genetic damage and mutations, bystander damage may also include genomic instability which manifests only after many generations of cell divisions among populations of non-targeted cells. The mechanisms responsible for the bystander effect are not currently known. Two separate pathways seem to be involved. In cells which are in direct contact with each other, chemical communication from the irradiated cell to unirradiated neighbors occurs through channels called gap junctions. For communication with more distant cells, the prevailing hypothesis is that the hit cell releases damage-response chemical signals into the intercellular medium which are then absorbed by cells not directly targeted by the radiation.

The bystander effect shakes the foundation of orthodox dogma as to how radiation interacts with living systems and calls into question the adequacy of current models of radiation risk. Although as yet unproven, it suggests that internal exposure to low doses of radiation may be more hazardous than currently assumed. Further, it poses a serious challenge to the reigning assumption that the effects of low doses of radiation can be determined by a simple linear extrapolation from high doses:

> [The bystander effect] would have significant consequences in terms of radiation risk extrapolation to low doses, implying that the relevant

> target for radiation oncogenesis is larger than an individual cell, and that the risk of carcinogenesis would increase more slowly, if at all, at higher doses. Thus a simple linear extrapolation of radiation risk from high doses (where they can be measured) to lower doses (where they must be inferred) would be of questionable validity (Hall).
>
> The bystander effect does not demonstrate a linear relationship to dose. It is maximally induced by very low doses, suggesting a switch on/off mechanism for its activation (Belyakov *et al.*).
>
> On the basis of this [bystander] effect and its possible contribution to cancer induction in body tissues via the induction of DNA damage, the authors question the assumed linearity of low dose carcinogenic response for alpha particles; this assumption is an important element in radiological protection (Zhou).
>
> The main report [CERRIE Majority Report] notes that the existence of genomic instability together with the bystander effect draws attention to the existence of organization levels for cell communication midway between the cell and the organ. Sonnenschein and Soto have recently suggested that such cell communities are pivotal in the development of cancer as it is cell communication from local cells that tends to prevent any cells in a community from running away from growth control. They see replication as a default state and quiescence as a response to control by local cells. This suggests that damage to such a cell community results in transformation and may be critical in the ultimate expression of cancer. For this reason sublethal damage from multiple decays from hot or warm particles would confer risks not accommodated within presently accepted paradigms (CERRIE Minority Report).

It is interesting to note that the existence of the bystander effect lends support to the idea put forth in Exhibit A that radiation effects cannot be adequately modeled by the simple concept of a transfer of energy. "**Because of bystander effects, the distribution of energy in cells is not related to the distribution of cellular damage"** (Brooks).

The bystander effect introduces an entirely new type of effect produced by ionizing radiation, namely a disruption of intracellular and intercellular communication pathways. The study of this phenomenon is in it infancy and may lead to a revolution in understanding radiation effects. Rosalie Bertell has provided a few insights into this fascinating avenue

of research:

> In addition to these general affects on the whole organism, there are micro-biological effects and biomarkers of exposure which have been neglected by the ICRP because of their focus on cancer death and only one mechanism, namely, direct damage to the DNA molecule initiating a malignant growth. Professor Michael Vicker, University of Bremen, has documented the acute radiosensitivity of blood to micro-Gray doses of radiation, causing the arachidonic acid cascade (Vicker). Rather than trying to extrapolate the DNA damage hypothesis from the high dose exposures to radiation into theoretical happenings in the low dose range, researchers would do better to expand the mechanisms studied to include those which actually occur at the low dose and their sequelae.
>
> With all of the sweeping changes which have occurred in biology and microbiology since the 1952 discovery of DNA by Watson and Crick, radiobiology has stayed focused on cancer and direct damage to DNA. Other branches of biology have expanded to consider the entire cell, systems influencing cellular behavior including functional levels and coupled feedback reactions of networks of inter- and intra-cellular responses regulating cell communication. Without a holistic view of biology and physiology, radiobiology has been consumed with detail and elaborate mathematical picture of the small world which was delimited by the very first administrative decisions of the nuclear bomb era.
>
> In an organism, cells communicate with one another through the exchange of specific information, for example through a hormone, and the translation of this signal into intracellular messages. Paracrine (hormones secreted from tissues other than endocrine glands) and endocrine hormones are unable to pass through cell membranes. Therefore their information (the hormone) requires a cellular receptor on the outside surface of the cell, a transmembrane signaling that is connected to the receptor, called a "second messenger-generating enzyme", and a correct interpretation of the second messenger system. Various second messengers are released into the cell after stimulation of a particular receptor enzyme system, and which systems may be activated depends on the genetically determined receptors possessed by the cell. This communication system between cells in complex systems, can be modified, for example by phosphorylating particular proteins, and two second messengers can

interact through feedback and cross talk. Ionizing radiation causes many interferences and disruption in this delicately balanced intercellular communication system. In radiobiology, these problems are dismissed and assume to be either trivial or perfectly repaired. Ionizing radiation induces oxidative stress, something admitted by radiobiology but discussed only in terms of its thermal effects. This same oxidative stress induces measurable inflammation, including a massive cascade of fatty acids in various states of oxidation. These mediate inflammatory reactions in the blood and other tissues, such as blood vessel endothelium, and function as second messengers, even controlling such things as pain and chemiluminescence.

The perturbation of cellular communication, regulation and homeostasis by low doses has major consequences for human health and development. It is irrational, as the physicists are now doing, to count on the failure to observe high dose effects at low doses as "proof" that such doses are "safe". DNA damage is a statistical phenomena, called stochastic by the physicists, while the inflammatory response is non-stochastic, or deterministic as it is now called. Unlike skin burns, these internal inflammatory responses occur at microGray doses. The ICRP assumes that deterministic effects do not occur below 500 mGy doses.

The ionizing radiation stimulations are "illicit" in the sense that there is no equivalent stimulation of the arachidonic pathway after non-radiological physiological stimulation, making it pathogenic in character, difficult for the body to regulate and return to homeostasis. This response activates the monocytes, which kill themselves by the oxidants they produce, often ending up as pus along with their digested cellular victims. They can endanger the host by killing other tissue, for example, transplants or infarcted heart tissue.

Activated monocytes are carcinogenic, provoking hitherto latent oncogenic systems and genomic errors to replicate. This may well be one of the mechanisms by which cancers were increased within the first ten years after the Chernobyl disaster. These cancers were dismissed by the IAEA as not radiation related because the ICRP required latency period of ten years had not been completed. These were radiation promoted or accelerated cancers, not radiation induced cancers. Again, we see ICRP recognizing only radiation induced cancers, whereas the victim will experience both mechanisms as due to the disaster (Bertell, February 1998).

In addition to genomic instability and the bystander effect, there are other biological phenomena not adequately represented in the ICRP model of the health effects of radiation. For instance, cells vary in their sensitivity to radiation at different times throughout their lifespan. In an experiment conducted in 1966 on Chinese hamster cells, a 600-fold variation was observed in cell radiation sensitivity throughout the entire cell cycle (Sinclair and Morton). At any one time during the life of an organism, most cells inhabit a phase commonly referred to as Gap 0 (G0). In this phase, the cell is in a non-replication mode of stasis. It is living out its life while contributing to the normal living processes of the system of which it is a part. While in this phase, the cell is *relatively* insensitive to radiation damage. At some point, as a result of such factors as tissue growth, damage, or senescence, a signal is generated to initiate cell replication and the cell moves into Gap 1 (G1) phase. At this point in the cell cycle, preparations are initiated for the replication of the chromosomes. The cell increases in size, produces RNA, and synthesizes proteins. Also, an important cell-cycle control mechanism is activated. A process of proofreading of the integrity of the DNA gets underway where complementary strands are compared and damage is repaired. During G1, the cell is in an intermediate state of sensitivity. If the cell is damaged at this point by radiation, a period of delay is introduced into the process of cell replication while any newly incurred damage is repaired. In this controlled sequence of preprogrammed operations, the cell then moves on to Synthesis (S) phase where the chromosomes replicate. From there, Gap 2 (G2) phase follows. During this gap between DNA synthesis and cell division, the cell continues to grow and produce new proteins. Late in G2, a last checkpoint is reached in the cell cycle to verify that the cell is ready to enter mitosis and divide. Once this transition point (TP) is passed, the cell has reached a point of no return in the sequence of events and it will undergo mitosis. At this transition point, the cell is at its most sensitive point for radiation damage. If a sublethal hit is incurred at this time and damage is introduced into a chromosome, repair is not possible. The damage will be copied and replicated in the two daughter cells regardless of the amount of damage.

The ICRP model makes no allowance for the varied sensitivity of cells throughout their lifetime. Yet again ignoring radiation effects on the cellular level, the model is out of touch with basic biological realities. This gross inconsistency, however, does serve one important purpose. It bolsters the archaic and inappropriate concept of dose which averages energy over large volumes of undifferentiated, noncellular, masses. By this means, low-level radiation effects to individual cells is afforded no room for consideration within the current paradigm of radiation safety. The hazard posed by internal emitters is thus conveniently sidestepped. The enhanced sensitivity of cells to radiation damage at the time of replication suggests that the energy/particle flux from internal emitters, even at low doses, may represent an enhanced hazard to radiation injury when compared to photons impinging on the body from the outside from naturally occurring background radiation due to dif-

ferences in ionization density. It has been determined that, as a result of the natural radiation from the environment impinging on the body externally, each cell receives on average one hit per year. In contrast to this low-level external radiation, low-level radiation emitted by radioactive particles embedded within the body have a greater likelihood (dependent, of course, on quantity and activity) of hitting cells in their immediate proximity during the period of heightened sensitivity of cell replication.

The varying sensitivity of the cell to radiation throughout its life cycle is a central feature of Dr. Chris Busby's Second Event Theory. According to this theory, particular radionuclides that undergo sequential radioactive decay and "hot particles" (particles made up of a number of radioactive atoms) represent a unique hazard when immobilized in the body as compared to random hits delivered by natural background radiation. Central to Second Event Theory is the concept of time between hits to a cell, a factor not taken into account by current assessments of risk from radiation. According to Busby's theory, certain types of sublethal radiation damage created by a single track through a cell can stimulate the cell to undergo a repair and replication sequence. This lasts for a period of between eight and fifteen hours. If the cell is hit again — the second event — while it is at the point of heightened sensitivity in the repair cycle, irreparable sublethal damage may occur in the form of a mutation that will be passed on to daughter cells. Given that natural background radiation is responsible for but one hit per year per cell, on average, only a remotely small probability exists that this source will produce two hits to the same cell within the timeframe of heightened vulnerability to irreversible genetic damage during cell replication. However, the same cannot be said for some types of internal emitters. For instance, strontium-90 has a half-life of twenty-eight years. When it undergoes radioactive decay inside the body, it will hit nearby cell(s) with its emitted beta particle. Having decayed, the atom will have been transformed into yttrium-90. Yttrium-90 has a short half-life of sixty-four hours. The possibility thus exists that this yttrium atom will undergo radioactive decay within the period of maximum susceptibility of the nearby previously hit cell and strike it a second time with its emitted beta particle. In this way, an internalized sequential emitter can be responsible for two hits to the same cell during the window of opportunity of non-reparable genetic damage. A number of other sequential emitters can be similarly hazardous. For instance, tellurium-132 has a half-life of seventy-eight hours. By beta decay, it transforms into iodine-132 that has a half-life of 2.28 hours. Similarly, barium-140 possesses a half-life of 12.8 days and decays into lanthanum-140 with a half-life of forty hours. It is crucial to emphasize that sequential emitters are not the sole source of second-event processes. A "hot" particle can produce the same effect. A particle of plutonium entering into the lung can be made up of billions of atoms. Once lodged in place, it will continue, on an ongoing basis, to shower nearby cells with alpha particles. Two hits to the same cell within the proper time period can be responsible for inducing mutations in hit cells that will

be passed on to daughter cells. This is a plausible pathway for the initiation of a cancer. Not to be forgotten in the latter portion of this book is this important fact: A particle of depleted uranium has the capacity of inducing multiple hits to the same cell during that cell's period of maximum vulnerability. Depleted uranium is quite capable of causing genetic damage and inducing mutations within cells in its immediate vicinity. Once again the propagandists are shown up as liars. Depleted uranium internalized into the human body does pose a radiological hazard.

When one takes into account the differences in cell sensitivity to radiation at different times in the cell life cycle, the hazards of low doses of radiation may be much greater than that supposed by ICRP models. According to the ICRP, radiation effects are proportional to dose. This linear relationship is well-documented at high doses, and via mathematical extrapolation, it is assumed to be equally true at low doses. However, when taking cell sensitivity into account, the dose-response relationship at low doses takes on a different picture. It is not unreasonable to assume that throughout an organ or throughout the whole body, some portion of cells at any one time are undergoing replication. Normal replacement of dead or aging cells can account for this turnover. When this subgroup of sensitive cells is factored into consideration, the concept of averaging a dose over an undifferentiated mass to derive an organ dose once again seems out of touch with reality and the linear dose-response model breaks down at low doses. A biphasic dose-response relationship would offer a more accurate model of low-dose effects to cell populations that include among them cells in a state of hypersensitivity to radiation damage. Such a response has been observed by Burlakova (Burlakova 1995, 1996). To explain, let's assume that one percent of a cell population is actively dividing and in repair replication sequences, and for argument's sake, that these cells are 200 to 600 times more sensitive to a hit from a radiation track. What would the dose-response look like?

> Well, as the dose was increased from zero, the sensitive cells would begin to be damaged and a proportion of these hits would result in fixing a mutation and increasing the possibility of cancer. As the dose increased further, eventually this rise in response would peak as these sensitive cells were killed. The mutation yield would then begin to fall. However, at some point, the insensitive G0 cells would begin to be damaged and the whole process would begin again, with a rise in cancer (Busby 2000).

It can be seen from this model that the lowest doses of radiation can induce mutations in the most sensitive cells. Thus, the likelihood of developing cancer may be enhanced at low doses. As the dose rises, these most sensitive of cells are killed preventing cancer expression. This has the effect of masking the low-dose mutagenic effect. As the dose

increases further, the cells in G0 begin to be damaged and the dose response begins to take on the linear appearance that is currently assumed to be true for all doses. Within this theoretical framework, the possibility emerges yet again that internal emitters releasing low doses of radiation may pose a greater hazard than currently assumed by a simple linear extrapolation from high doses of radiation delivered external to the body.

It is reasonable to hypothesize that in the case of fetal injury, dose-response cannot be linear, but must be biphasic. This point is clearly addressed within the Minority Report of CERRIE, the Committee Examining Radiation Risk in the Environment:

> The Committee [CERRIE] considered the effect that the assumption of a continuous linear dose response relationship would have on the interpretation of findings in epidemiological studies. We [those who authored the Minority Report] argued that this (assumption that increasing dose would consistently produce increasing effect) was biologically implausible — for example, increasing dose to the fetus would ultimately result in its death. As a consequence, if an analysis of any endpoint in infants were expressed in terms of increasing dose it would show a maximum followed by a reduction. If there were sub populations of cells or people of different sensitivity, there could then be a subsequent increase (a biphasic dose response) (CERRIE Minority Report).

The biphasic dose response to low-dose/slow-dose rate exposure was proven by Burlakova and her colleagues after extensive research on animals and humans. This work was summarized in an article by Rosalie Bertell entitled *Gulf War Syndrome, Depleted Uranium and the Dangers of Low-Level Radiation*:

> They [Burlakova and fourteen other scientists] examined carefully the following biological phenomena under ionizing radiation exposure situations:
>
> * alkaline elution of DNA of lymphocytes and liver
> * neutral elution and adsorption of spleen DNA on nitro cellulose filters
> * restriction of spleen DNA by EcoRI endonuclease
> * structural characteristics (using the ESR spin probe technique) of nuclear, mitochondrial, synaptical, erythrocyte and leukocyte membranes
> * activity and isoforms of aldolase and lactate hydrogenase enzymes
> * activity of acetycholine esterase, superoxide dismutase, and glutathione

peroxidase
* the rate of formation of superoxide anion radicals
* the composition and antioxidizing activity of lipids of the above mentioned membranes
* the sensitivity of cells, membranes, DNA, and organisms to the action of additional damaging factors.

> **For all of the parameters a bimodal dose-effect dependence was discovered**, i.e. the effect increased at low doses, reached its [low-dose] maximum, and then decreased (in some cases, the sign of the effect changed to the opposite, or "benefit" effect) and increased again as the dose was increased. Dr. Burlakova has speculated that at the lowest experimental doses used in this research, the repair mechanism of the cells was not triggered. It became activated at the point of the low-dose maximum, providing a "benefit"[7] until it was overwhelmed and the damage began again to increase with dose. This may well be the case.

There are numerous other examples of biological effects not adequately considered by ICRP risk assessments. For instance, some people are genetically predisposed to a heightened sensitivity to radiation damage. Are these people adequately protected by current radiation standards developed in the one-size-fits-all model of the ICRP?

> Animal and human studies have identified genetic subgroups with enhanced sensitivity to radiation e.g. Japanese LSS study and women developing early breast cancer. In the extreme cases of those carrying the ATM gene for *ataxia telangiectasia*[8], there is extreme radiosensitivity and tendency to leukemia, lymphoma, and some solid tumors (ECRR).

Take another example of biological variations among people outside the purview of ICRP models. Not everyone's immune system functions identically. Immune response to radiation insult may differ significantly from person to person. Models ignoring the variations may put segments of the population at greater risk to radiation injury. Further, the

[7] It is important to note that it is only within this narrow dose range, where cell repair mechanisms begin to kick in, that the concept of hormesis makes sense. The concept, however, is abused when cited to prove that low-dose exposure is "beneficial" to the organism. Burlakova has demonstrated that numerous detrimental effects occur at lower doses before this seeming "benefit" appears.

[8] A rare, inherited, progressive, degenerative disease of childhood that causes loss of muscle control, a weakened immune system, and an increased risk of cancer.
http://www.cancer.gov/dictionary/db_alpha.aspx?expand=A#ataxia-telangiectasia

immune system performs defensive surveillance on behalf of the body and can mitigate the effects of mutation or tumor progression induced by radiation. However, the effectiveness of this system can be suppressed by exposure to certain stressors such as ultraviolet light. This suppression of immune system response may, under some circumstances, be another factor involved in the enhancement of hazard from low doses of radiation.

Take a third example. It is a well-established fact that different radioisotopes, due to their chemistry, have an affinity for different organs of the body. This fact is acknowledged in ICRP models, and the hazard posed by different radioisotopes to different organs is adequately taken into account. But the same consideration is not given to radioisotope affinity on the molecular level. For example, it has been proven that Uranyl UO_2^{++} ions bind strongly to DNA (Wu). This suggests that internalized depleted uranium may have an affinity for DNA molecules. Thus, depleted uranium may pose an enhanced hazard to genetic damage out of all proportion to its "dose." The same is true for strontium isotopes which have affinity for the phosphate backbone of DNA. It is essential that such molecular affinities be incorporated into assessments of risk from radiation because molecular effects at extremely low doses may nonetheless induce serious consequences to health in the form of mutations.

Another phenomenon ignored by ICRP models is the chemical transmutation radioisotopes undergo upon radioactive decay. When an atom undergoes transformation from one element to another, the chemical bonds which it has formed can be broken leading to significant alteration of the molecular structure of which it was a part. The impact of this chemical change is mentioned in the publication of the European Committee on Radiation Risk.

The macromolecules which are the operators of living systems — proteins, enzymes, DNA and RNA — depend upon their tertiary structure, or shape, for their activity and biological integrity. Alteration of this shape results in inactivity of the macromolecule. This inactivation could in principle be effected by the sudden transmutation or alteration of one atom in the macromolecule. Since the molecular weight of these macromolecules is usually greater than 100,000, it is clear that incorporation of one atom (of e.g. Carbon-14 which decays to Nitrogen) may result in an enhancement of effect of many thousand-fold (ECRR 2003).

When radioisotopes enter the internal environment of the body, they are available to become incorporated into the structure of significant macromolecules. Upon radioactive decay of just one atom in such a molecule, the function of the entire molecule may be altered or destroyed. A question yet to be addressed in risk assessment is the impact to

health on individual cells, organs, and the whole organism of such altered molecular junk flooding the human body.

The ECRR mentions another interesting biological phenomenon that may in time prove important in risk assessment. In a recent theory of cancer expression hypothesized by Sonnenschein and Soto, a communication field exists between cells, and a threshold number of genetically damaged cells must come into existence before cancer can develop (Sonnenschein and Soto). This idea is based on the theory that cell proliferation is the default state in multicellular organisms and that some permanent inhibitory signal must exist to deter proliferation. It is postulated that this inhibitory signal is carried by cell-to-cell communication and is perpetuated in the field of this communication network. "If this is found to be generally so then the effects of high local doses, as occur in the region near hot particles, may be particularly effective in causing cancer, since the damaged cells are all close to one another" (ECRR). By this theory, hot particles can create sufficient local damage to disrupt the inhibitory signal generated between cells and lead to cancerous proliferation.

One last biological phenomenon mentioned by ECRR that has yet to enter into consideration by ICRP models is the transfer of radioisotopes to the developing fetus in a woman who is internally contaminated. Once again, alpha emitters released at extremely minute concentrations may have consequences out of all proportion to the "dose" as currently calculated by ICRP models.

> For early developing fetuses, the local dose from particles of plutonium oxide or other actinide alpha emitters will be massively high and may result in a range of effects from fetal death and early miscarriage to effects in childhood. This is a case where the biological end-point may result from a very low probability, high risk event (ECRR).

To conclude Exhibit D, it is necessary to reiterate that the computational system developed during the Tri-Partite Conferences and carried into the NCRP and ICRP was an outstanding achievement in mankind's quest to manage the hazards to health posed by internal contamination by radionuclides. The system reduced to manageable abstractions the complex array of variables that were involved in the biological behavior of radionuclides. This permitted reasonable first approximations to be derived of what might constitute a nonhazardous dosage of radiation. To quote Rosalie Bertell:

> There are many administrative decisions embedded into the elaborate (artificial) methodology for calculating effective whole-body dose and for calculating the expected number of radiation-induced fatal can-

> cers. The strengths of the ICRP approach rest primarily on its ability to quickly convert a multidimensional problem, that is, a mixture of radionuclides, having a variety of energies and types of emissions, multiple pathways to humans, and a variety of target human organs, into a linear system amenable to management decisions. This is a recognized mathematical achievement. However, in risk assessments, long-term chronic exposure, the aftermath of a disaster, or in worker compensation hearings, these same techniques cloud reality and work effectively against justice for the victims. The elegant mathematics must not be allowed to cover up the injustices (Bertell, February 1998).

For all its strengths, the ICRP model is deeply flawed in one significant respect. It breaks down when it is applied to low-dose effects produced by internal emitters. The effort to prop this model up where it cannot adequately account for observed biological phenomena and to force reality to conform to the model is the source of the injustices alluded to by Rosalie Bertell. As outlined in this Exhibit, there exists a wide range of biological phenomena capable of being produced by low doses of internal emitters that cannot be addressed by current models of risk as propounded by the radiation protection agencies. These agencies represent their models as the definitive statement of how radiation affects the human organism, but this is, at best, a half-truth. Vast regions of uncertainty exist which are currently ignored in risk assessment. This is not without consequence for the welfare of humanity. Governments exploit the flaws in the current model to rationalize the safety of their nuclear/radiological agendas. Under these circumstances, there is no mechanism in place to constrain their deeds. With science rendered impotent to testify before humanity the crimes of governments, and with scientists incapacitated by falsehood to stand up for the health and welfare of humanity, governments are in effect carrying out radiation experiments on the entire human race. Rather than respecting the biological phenomena coming to light through modern research and curtailing their activities in the name of caution and respect for life, governments are ignoring biology in pursuit of their nuclear programs. Under such circumstances, the ICRP, NCRP, NRPB, UNSCEAR, and BEIR are ineffectual pawns at best, complicit criminals at worst, supporting the reckless endangerment of all life on planet Earth by offering no force to counter the misdeeds of governments. The results of their flawed methodologies legitimize these misdeeds. These organizations never intercede on behalf of humanity by sending the message to government, "Wait! There are biological phenomena that are not sufficiently taken into account in our current understanding to justify the scattering of radioactivity throughout the environment!" Although they stand before humanity as agencies of protection to the human race, they are complicit in the furtherance of policies that are contaminating, and will continue to contaminate,

populations with radioactivity.

By ignoring the biological implications of their nuclear/radiological policies, governments have forced a scientific issue, which would normally be settled by trained professionals guided by the scientific method, into a political issue. By casting caution aside and flouting biological truths in their pursuit of unlimited power, governments have left citizens with no recourse but to enter into a political struggle to curb government abuses and rescue the biological domain. If the radiation protection community is unwilling to restrain imprudent government and military policy, there is no other way.

EXHIBIT E

In Exhibits A through D, we have examined glaring shortcomings in the current approach to radiation safety as it applies to low doses of internal emitters. We have pinpointed major flaws in the reigning paradigm of how radiation interacts with living cellular structure, the way dosage is calculated, the research used to justify and perpetuate these errors, and the biological effects that the current system cannot adequately address. With this groundwork prepared, we can carry a torch into the heart of darkness of the nuclear age. Egregious malfeasance crouches silently within the answer to a single question: *Why do radiation protection agencies continue to uphold an antiquated model of how internal emitters interact with living systems when assessing the hazards to health of ionizing radiation?*

In their book *Radiation Protection Dosimetry: A Radical Reappraisal*, Jack Simmons and David Watt are very generous in their assessment of the current state of affairs within the radiation protection community. They liken the continued reliance on "absorbed dose" for assessing low-level radiation effects to the planetary system developed by Ptolemy that perpetuated the false notion for 1,400 years that the Earth was the center of the universe. In the *Almagest,* published in the middle of the 2nd century A.D., Ptolemy presented a mathematical theory for the motions of the Sun, the Moon, and the planets. According to the theory he proposed, the Earth was suspended in the center of the universe. The stars were fixed points of light on the inside of the celestial sphere. The alternation of the day and the night resulted from the rotation of the entire celestial system around the Earth. To account for the motion of the Moon, Mercury, Venus, Sun, Mars, Jupiter, and Saturn, Ptolemy proposed that the planets moved on small circular paths, the epicycles. The centers of these epicycles, the imaginary points around which the planets circled, in turn orbited the Earth along great circular paths called deferents. To fully account for the ongoing accumulation of astronomical measurements, including the peculiar retrograde motion of

some of the planets, a number of correction factors were periodically introduced into the system that compounded its complexity. Although unwieldy, the model was adhered to for fourteen centuries for its apparent accuracy in explaining observations and its ability to forecast future movements of the planets across the heavens. However, as the centuries passed, astronomical measurements accumulated that produced increasing discrepancies between observation and theory. By about 1500, many investigators doubted the correctness of the Ptolemaic system. This growing lack of confidence in established doctrine provided fertile ground for the conceptual revolution introduced by Copernicus. To account for all available observations, Copernicus inaugurated a paradigm shift, proclaiming that the Sun was the center of the universe, and the Earth, spinning on its axis, circled the Sun along with the other planets.

Simmons and Watt argue that the current system for calculating dosages of radiation and relating these dosages to observed biological effects is analogous to the Ptolemaic system. Over the last half century, an enormous amount of data has accumulated on the biological effects of radiation. This expanded knowledge base has forced the introduction of multiple correction factors into the models for calculating dosage and dose effects developed during and after the Manhattan Project in order to rescue these models from obsolescence and irrelevance. At this point, according to Simmons and Watt, the current methodology is unwieldy and incapable of accounting for the full range of confirmed observations. The time has arrived for a paradigm shift to bring theory more into line with observed phenomena.

This explanation for the continued embrace of an outdated model of radiation effects is naive. It fails to acknowledge and address the political interests that are so faithfully served by the perpetuation of the timeworn model that the radiation protection agencies insist on clinging to. Given that the current system for determining dosages of radiation and calculating biological effects does such an excellent job of protecting government and commercial nuclear programs from liability and criticism by the public, it is legitimate to ask whether another explanation exists as to why faulty models, out of synchronization with modern research, are allowed to dictate radiation safety.

The thesis to be developed here is straightforward. The faultless work of the Tri-Partite Conferences and Subcommittee Two underwent a sinister metamorphosis in the years subsequent to its development at the hands of government scientists and administrators who were sympathetic to nuclear weapon development and the proliferation of commercial nuclear power. In response to the government initiative to impose nuclearism on its citizenry, sectors of the public, beginning in the mid-1950s and continuing up to today, began to acquire a rudimentary understanding of radiation effects and embarked upon a

path of vocal opposition and protest against the government agenda. Simultaneously, research conducted by independent scientists began appearing with increasing frequency in scientific journals that revealed that catastrophic health effects were being created by the radioactivity which was routinely jettisoned into the environment. Amidst growing social unrest, the Atomic Energy Commission and its successor agencies, the Energy Research and Development Agency and the Department of Energy, were forced to pursue increasingly sophisticated methods of controlling the *perception of hazard* of the radioactivity being spewed over the population and infiltrating the food supply. Each radiation release, as it became known to the public, required a state-sponsored public relations campaign crafted to keep the citizenry ignorant of the potential medical consequences accompanying that release. Within this charged political climate, the information officers and radiation physicists who were sympathetic to the government's nuclear agenda discovered an unintended consequence of the work perfected by Subcommittee Two: **The computational system developed for computing dosages from internal emitters contained within it all the makings for an instrument of deception**. While struggling to portray each radiation release in the most benign light by repeatedly running numbers through their equations until they produced the desired results, the propagandists chanced upon the discovery that the computational system could be re-engineered into a political device for masking the medical significance of radioactivity delivered into the human body in low doses from internal emitters. By this conversion, the dosages delivered to exposed populations and the medical implications of these dosages could forever be manipulated so as to give the appearance of being of no consequence. Servants of the nuclear agenda realized they were heirs to a masterful propaganda tool. In their hands, the accepted methodology for calculating dosages from internal emitters, and thus how the public perceived the hazards thrust upon them, could be mathematically manipulated so as to trivialize the quite real threats to health. By computational abracadabra, all dosages to vulnerable populations downwind of liberated plumes of radioactivity could be made to appear within the permissible limits upheld by the international radiation protection community. What started out in Subcommittee Two as an effort to protect people from radiation was transformed into a vehicle of fraud for masking the potential health consequences of government-sponsored nuclear programs.

Although paying lip service to the hazards of fallout throughout the era of above-ground weapon testing and in the aftermath of radiation releases from nuclear facilities, the government's entire nuclear program since Hiroshima has hinged on the public remaining ignorant about the phenomenon of internal contamination. The cover-up began in earnest in the years immediately after the Second World War. In 1946, the United States demonstrated to the world its nuclear might by detonating two atomic bombs in the Bikini Atoll of the Marshall Islands. In 1947, and again in 1949, teams of researchers from the

Laboratory of Radiation Biology of the University of Washington traveled to Bikini to study the ecological impact of the radiation releases. For the first time, it was observed that plants and animals incorporated environmentally deposited radioactivity into their internal structures. Investigating the local food chains, they discovered that radioactivity accumulated in ever-increasing concentrations within organisms along each step of the food chain with the highest internal concentrations found in the feeders at the top of each chain. From then onward, internal contamination by fallout could not be honestly denied. But that is exactly what the Atomic Energy Commission did habitually when weapon testing commenced in 1951 at the Nevada Test Site and the Pacific Proving Grounds.

There is no need to dwell at length on the cover-ups and deceptions perpetrated by the Atomic Energy Commission against the American people in regard to the hazards of nuclear pollution. It is an ugly, undeniable fact, substantially documented in the historical record.[9] (The problem we are chasing here is that essentially nothing has changed today from the time when the AEC was in charge of radiation protection except for the fact that the lies and deceptions have become more sophisticated.) To protect the nation's weapons program and the monied interests' investment in commercial nuclear power, the AEC was forced onto a precipitous tightrope act between managing the hazards of fallout and the need to cause as little alarm as possible throughout the population. Success in this balancing act required the pretense of absolute safety to the population from low-level exposure to fallout.[9] Despite the fact that the NCRP had adopted the position in 1948 that no-threshold dose existed for the onset of radiation injury, "for several decades, AEC officials continued to publicly assert that there was a threshold of safety and that its exposure limits [the dosages deemed permissible to the public] were below that threshold" (Caufield). In harmony with this deception, the AEC published in a pamphlet in 1953 that argued that "low-level exposure can be continued indefinitely without any detectable bodily change When publishing information on the offsite drift of radiocontaminants from the Nevada Test Site, the hazard of fallout was routinely trivialized and always explained in terms of

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[9] For those interested in researching this travesty, a number of popular histories appeared in the 1980s documenting the AEC's coverup of radioactive contamination of the American public. Although not currently in print, copies can still be found in libraries and used bookstores. A few titles follow:
Fallout: An American Nuclear Tragedy by Philip L. Fradkin
Justice Downwind: America's Atomic Testing Program in the 1950s by Howard Ball
Multiple Exposures: Chronicles of the Radiation Age by Catherine Caufield
The Cult of the Atom by Daniel Ford
The Day We Bombed Utah: America's Most Lethal Secret by John G. Fuller
Under the Cloud: The Decades of Nuclear Testing by Richard L. Miller
Killing Our Own by Harvey Wasserman, Norman Solomon, Robert Alvarez, and Eleanor Walters.
This volume can be downloaded from the internet in its entirety at
www.ratical.com/radiation/KillingOurOwn/KOO.pdf - 1035k.

potential external exposure. Thus, news releases from the AEC were forthright as to the intense burst of gamma rays at the moment of detonation and the hazards of gamma emitters in fallout. But to minimize the perception of hazard, reassurances quickly followed, informing people that the gamma burst was geographically limited to the immediate vicinity of a blast and that radionuclides in fallout rapidly decayed and were quickly dispersed throughout the environment in harmless concentrations. The possibility of internal contamination was left totally unmentioned or downplayed as insignificant. The AEC was fully cognizant of the hazards of internal contamination but kept the subject out of the public domain. Robert Minogue, a research director for the Nuclear Regulatory Commission once said, "High AEC officials knew very well the biological effects of low-level radiation in the 1950s. They can't use ignorance as an excuse" (Wasserman *et al.*). The fallback position on internal contamination repeatedly professed by the AEC was that, if external gamma radiation was within the established safety limits, the internal buildup of dangerous levels of radionuclides was unlikely. When queried, the AEC rationalized its position with a number of flagrant lies and ill-conceived notions about internal contamination, claiming that released radionuclides were characterized by

> (1) a short half-life so the radiation would not persist long enough to deliver a harmful dose; (2) the lack of similarity to normal body constituents so that retention would be very small; (3) if passed through the metabolic processes of the human food chain, decay and insignificant retention would appreciably diminish any potential hazard; (4) that normal food preparation would be expected to remove most of the deposited radionuclides; and (5) that wind-borne fallout clouds at distances far from the NTS would not maintain atmospheric concentrations long enough for inhalation to be a significant route of exposure. Therefore the emphasis was placed on minimizing the external exposure of the offsite population (Black and Potter).

With the passage of time, the lies told by the AEC were exposed. Today, the agency's legacy is the monumental betrayal of the American people that included the following misdeeds:

1. Failure to provide adequate warning to people living downwind of weapon tests.
2. Failure to develop an adequate radiation monitoring system.
3. Failure to explain to exposed populations the increased health risk confronting children.
4. Failure to warn of the hazard to livestock grazing on contaminated land.

5. Failure to inform about food-chain contamination.
6. Failure to inform those at risk about what steps could be taken to minimize their exposure.
7. Failure to disclose the results of research on the health effects of fallout.

Despite every effort by the AEC to downplay the danger of the inhalation, ingestion, and absorption of radionuclides liberated into the environment, evidence began accumulating throughout the 1950s that ignited widespread concern. Reports from downwinders began to appear in the press documenting hair loss and skin burns, poisoned wells and dead livestock. Fission products, particularly strontium-90 and cesium-137, began to be detected in the nation's food supply. High concentrations of iodine-131 were discovered in dairy products of communities downwind of the Nevada Test Site and in the thyroid glands of the children consuming these dairy-based foodstuffs. The Baby Tooth Survey provided unmistakable evidence that strontium-90 was accumulating in the teeth of children in all areas of the country. Suspicion and fear began to surge about the possibility that radionuclides released from weapon tests were causing increased incidences of infant mortality, leukemia, thyroid disorders, and cancers. These combined revelations erupted in a crescendo of vocal protest, both in this country and abroad, that was a key factor in bringing the United States and the Soviet Union together for the signing of the Limited Test Ban Treaty in 1963. But the end of atmospheric testing did not put an end to the public's distrust of the Government. In the decades that followed, waves of protest rolled across the country over such issues as the siting and safety of commercial nuclear power plants; the siting of nuclear waste repositories; proposed production of the neutron bomb; government refusal to provide financial and medical compensation to atomic veterans, nuclear workers, and downwinders; the health hazards of living in proximity to weapon production facilities and nuclear reactors; Three Mile Island; and today, depleted uranium.

Against this backdrop of ongoing civil unrest, guardians of the government's nuclear agenda were threatened by an even more formidable onslaught. Scientists not under the thumb of the nuclear establishment began publishing research that cast serious doubts on the adequacy of the government's safety guidelines. One tactic the AEC routinely turned to was to offer reassurance that radiation exposure received from fallout was no greater than that routinely received by a diagnostic x-ray. [Here again, attention is focused on external exposure to the exclusion of internal contamination.] This stratagem started backfiring during the second half of the 1950s. In 1955, while collecting data on the effects of x-rays on unborn children, David Hewitt of Oxford University noticed a trend toward a 50% increase in the number of British children dying of leukemia. His statistics encouraged Dr. Alice Stewart of Oxford's Department of Preventative Medicine to search for the reason. Dr. Stewart discovered that the death rate from cancer among chil-

dren under the age of ten was double among children whose mothers received x-rays while pregnant. X-ray exams conducted during the first trimester created a 10-fold increase in risk that the child would develop cancer. Further, multiple x-ray exams had a cumulative effect, with the risk of cancer increasing with each x-ray performed. These quite revolutionary findings on the effects of low doses of radiation had a profound impact on the propaganda campaign on behalf of the militarized atom. Science testified before all mankind that levels of radiation previously considered harmless were responsible for inducing cancer.

In May 1957, E.B. Lewis published an article in *Science* demonstrating that the incidence of leukemia was directly proportional to the dose of radiation received and that there was no safe level of exposure. The following month, Linus Pauling, who twice won the Nobel Prize, published an article in *Foreign Policy Bulletin* announcing his belief that 10,000 people were dead or dying from leukemia as a result of nuclear weapon testing. The following year, Pauling published estimates of the public health impact from the massive release of carbon-14. According to his calculations, the bomb tests "will ultimately produce about one million seriously defective children and about two million embryonic and neonatal deaths and will cause many millions of people to suffer from minor heredity defects" (Pauling). Also in 1958, Andrei Sakharov, the "father" of Russia's hydrogen bomb, added credibility to Pauling's estimates by declaring that every megaton of nuclear explosive detonated in the atmosphere would create 10,000 deaths from the uptake of carbon-14. Based on the rate of weapon testing, he estimated that half a million people had already died by the mid-1950s and each following year the number would increase by two to three hundred thousand.

In 1963, Dr. Ernest Sternglass, a professor at the University of Pittsburgh Medical School published an extremely controversial article in *Science*. He calculated that, as a result of fallout over the previous two years, everyone living in the northern hemisphere received a radiation dose of 200 to 400 millirads, *roughly equivalent to a pelvic x-ray*. Testifying before the Joint Committee on Atomic Energy that same year, Sternglass cited Stewart's research on x-rays and the incidence of childhood cancer and estimated that the atomic tests of 1961 and 1962 would create an extra 800 childhood cancer deaths.

Sternglass profoundly rankled the nuclear establishment in 1969 with publication of the article "Infant Mortality and Nuclear Tests" in the *Bulletin of the Atomic Scientists* (Sternglass). [The magazine's managing editor, Richard S. Lewis, informed Sternglass that, both before and after publication of the article, he received calls from Washington informing him that publication of the article was a "grave mistake."] According to Sternglass's article, rates of infant mortality between 1935 and 1950 had been declining by 4% per year. With the advent of atmospheric bomb testing in 1951, the rate of decline slowed. When

bomb testing came to an end in 1963, rates of infant mortality resumed their downward trend. Sternglass calculated that the interruption in decline of infant mortality during the era of atmospheric testing represented a death toll in the United States of 375,000 infants before their first birthdays.

Up to the present, Sternglass has continued publishing data on the health hazards of low doses of radiation. But his work has been marginalized by the mainstream nuclear establishment.

> BEIR V [the 1990 publication of the Committee on the Biological Effects of Ionizing Radiation] does not list Sternglass in its index and astonishingly has no section on the infant-mortality effects of radiation. As far as the reader of this standard work on low-level radiation is concerned, Sternglass never existed and radiation has no effects on infant mortality (Busby 1995).

Dr. John Gofman was another scientist that began to express his doubts that the population remained unharmed by fallout. Gofman had been a staunch supporter of the nation's nuclear programs. He was a co-discoverer of the fissionability of uranium-233, and during the Manhattan Project, he had helped to isolate the first milligram of plutonium. He went on to become head of the biomedical section of the Lawrence Livermore Radiation Laboratory. In May 1963, the AEC had announced the initiation of a "comprehensive, long-range program exploring in greater breadth and depth . . . man-made environmental radioactivity and [its] effects upon plants, animals and human beings" (AEC). Gofman was selected to oversee the program, and he worked closely with Arthur Tamplin, a former graduate student. It was during this work that Gofman began to undergo a conversion. He became convinced that public health and safety were not top priorities during weapon testing or in the Government drive to develop commercial nuclear reactors. In May of 1966, Gofman and Tamplin published a report entitled "Estimation of Dosage to Thyroids of Children in the US From Nuclear Tests Conducted in Nevada During 1952 Through 1957." It contained a realistic picture of the spread of radioactive iodine across the country and dose estimates to children's thyroid glands from the ingestion of contaminated dairy products. Some original dose estimates had to be scaled down after consultation with the AEC. In 1969, Gofman and Tamplin made headlines that further aggrieved the AEC. Up until that time, the scientific community and the public had received repeated assurances that routine leakages and discharges of radionuclides from nuclear reactors would pose no threat to health. During the course of their research, Gofman and Tamplin came to the opposite conclusion. At a science symposium in San Francisco in October 1969, they reported that levels of radioactive effluent from nuclear reactors which were deemed safe would in truth kill large numbers of people:

> "If the average exposure of the US population were to reach the allowable 0.17 rads per year average," they warned, "there would in time be an excess of 32,000 cases of fatal cancer plus leukemia per year." And the deaths would occur "year after year." Thus they recommended an immediate lowering of the legal exposure limit by a factor of ten, to 0.017 rads (Wasserman 1982).

Gofman and Tamplin made other waves during 1969. After Sternglass published his article on infant mortality and weapon testing, the AEC approached Gofman to refute the findings. Gofman handed the assignment to Tamplin, who reviewed Sternglass's research. The opinion he arrived at was that the number of cases of infant mortality had been overstated. At most, fallout from atmospheric testing was responsible for only 4,000 infant deaths. Pleased by this, the AEC encouraged Tamplin to publish his findings in *Science*. But they urged him to omit all mention of infant deaths caused by fallout from nuclear weapon tests.

For their ongoing opposition to the nation's nuclear agenda, both Gofman and Tamplin were forced out of their jobs. "In 1973, as a casualty of his integrity, Dr Gofman lost his position in his laboratory" (Durakovic 2003). In 1975, having lost his staff and budget in a thinly disguised act of blackballing, Tamplin resigned his position with Lawrence Livermore Laboratory.

For his involvement in the nation's nuclear program, Gofman has made the following confession:

> I feel that at least several hundred scientists trained in the biomedical aspect of atomic energy — myself definitely included — are candidates for Nuremberg-type trials for crimes against humanity for our gross negligence and irresponsibility. Now that we know the hazard of low-dose radiation, the crime is not experimentation — it's murder" (Gould 1990).

The issue that refused to be buried was that low levels of radiation were a threat to health. The subject repeatedly surfaced in the scientific journals. It represented the gravest threat to the nation's nuclear programs. Nuclear weapon testing released radiation into the environment. Commercial nuclear power plants could not operate without venting radioactivity into the surroundings. If low levels of radiation were confirmed as dangerous, the public would be outraged. The government was cornered. To safeguard its nuclear programs, the government had to deny the hazard of low-level radiation. The government's position on low-level radiation was aptly summarized by Lieutenant General

Harry A. Griffith, the director of the Defense Nuclear Agency during the Reagan administration, when he testified in the early 1980s before Congress on the subject of compensation to victims injured by the nation's nuclear weapons initiative:

> [Griffith] recited a litany of possible horrors should compensation be granted. Griffith testified that relief measures for the offsite population would result in a lowering of current radiation health standards, thus endangering the continued operation of academic research programs, medical and dental procedures, nuclear power plants, industrial radiology, nuclear ships, and the nuclear weapons program.
>
> General Griffith also said that to encourage "the erroneous impression" that low levels of radiation were a health hazard would disrupt these programs in four ways. First, claims would be filed against the government and private industry that would place "a heavy burden" on these entities to disprove. Second, nuclear workers would become more difficult to recruit, and 'the potential loss of manpower would stagnate the nuclear program." Third, compensation under existing health standards would result in those standards being lowered and "essential activities could be continued only with greatly increased cost while others could not be continued at all." And fourth, legislative and judicial recognition that low levels of radiation were hazardous "would increase the anxiety of the general public — itself an undesirable phenomenon — and thereby increase resistance to productive and necessary programs" (Fradkin).

It is beyond the scope of this book to offer an exhaustive review of the popular and scientific opposition that arose in the second half of the twentieth century to the nuclear agenda. The point has been to provide just a sketch of the social context in which the government's efforts to coerce the nation into hosting nuclear weapons and reactors took place. Controversial and dangerous programs were thrust upon the American people. Many perceived these as reckless endangerment to public health. Research by scientists with impeccable credentials confirmed the perceptions of many citizens that the risks from radiation exposure were cause for legitimate concern. Waves of opposition from throughout the heartland repeatedly swept over Washington. Nuclear programs were under a perpetual state of siege. The government was forced to adopt a defensive posture in opposition to the very citizens it was supposed to represent. Much money and manpower was expended devising new tactics to dissuade the public from raising further opposition. When evidence began accumulating of the hazard to health from low doses of radiation, members of the nuclear establishment recognized that a point of crisis had been reached. A endgame had to be devised. Unmistakable proof of endangerment from low doses of radiation would

render all state-sponsored nuclear programs indefensible. The government would be exposed as culpable for injuring tens of millions of its citizens. Financial reparations would be demanded for the ill and families of the dead. Accusations of crimes against humanity might be lodged. The line in the sand had been drawn. At whatever cost, by whatever means, mainstream science could not be permitted to establish a link between low levels of radiation and ill health. This was the unprotected flank of the entire nuclear enterprise. Renegades to the nuclear agenda could mount a successful scientific attack over this ground and ruin the plans of the Cult of Nuclearists. To forestall this prospect, radiation science as it applies to public health was preemptively infiltrated and subverted. A system of radiation safety was implemented that successfully masked low-level radiation effects and the threat to health of internal contamination. Worldwide acceptance of the bureaucratic infrastructure that upheld this defective methodology enabled mainstream science to testify before all mankind that government-sponsored nuclear programs and commercial nuclear power plants were safe and posed no hazard to health of the general population. With this accomplished, the Cult of Nuclearists had erected an impregnable and unassailable fortress by which to protect all future uses of radioactive material. Effective opposition would be forever muted. To challenge government on the safety of any of its programs involving radioactive material would first require a successful challenge to the entire edifice of radiation protection guidelines and the orthodox methodology for calculating dosage and assessing risk. As long as this infrastructure maintained the facade of scientific impeccability, all antagonists would be cut off at the knees, unable to challenge on "scientific" grounds that nuclear and radiological programs were ruining the health of life on planet Earth.

As outlined earlier in this chapter, the development of units of measurement for dosages of radiation was a profound intellectual achievement. It enabled scientists to quantify the interaction of radiation with matter. Likewise, the work of the Tri-Partite Conferences and Subcommittee Two was a milestone in radiation safety, allowing scientists to make significant inroads into determining what might constitute hazardous levels of internal contamination. In the hands of unscrupulous scientists, however, these scientific achievements were redirected to serve a political purpose. Hiding within established scientific theory and legitimate protocol, these scientists transformed the science of radiation protection into a masterpiece of trickery and beguilement. As currently crafted, the methodology for calculating dosages of radiation to exposed populations and determining health risks from these dosages is weighted against ever establishing definitive proof of hazard from low-dose exposure from internal emitters. This is by design. The reigning paradigm dictating the current approach to radiation protection has been artfully constructed to mask low-level radiation effects. This faithfully serves the Cult of Nuclearists which has been scattering radiation over the Earth for half a century. Science has been kidnapped to

intentionally hide the destructive health consequences to all life on Earth by the nuclear programs of the government.

It is alleged that the Cult of Nuclearists perpetrates a conspiracy against the people of the Earth so as to pursue its unquenchable thirst for developing nuclear/radiological weapons and procuring centralized control of the production of electricity through nuclear power. They hide the poisoned fruit of their nefarious deeds, radioactive pollution of Nature and the people of the Earth, behind inaccessible and fraudulent scientific models. They depend upon the international radiation protection agencies to enshrine these models and make them unassailable. With this infrastructure in place, every radiation release can be made to appear as inconsequential to health. Numbers are generated to "scientifically" verify the harmlessness of each release and demonstrate that dosages fall within limits accepted as permissible by the standard setting agencies. With no recourse to any other point of view, the public is forced to accept the opinion of the "experts." Most insidious is the fact that a whole generation of health physicists has been indoctrinated into the prevailing paradigm so as to unquestionably uphold the instrument of deception used to validate and protect the Cult of Nuclearists. Occasionally, scientists sufficiently trained in the radiation sciences to appreciate the fraud being perpetrated emerge to offer testimony against the corrupted paradigm. The defenders of the status quo then work to have these "rogue" scientists spurned and have their scientific work marginalized. The science of radiation protection, once conducted under the spirit of the search for truth, has been transformed by governments into an instrument of intellectual enslavement and the perpetuation of ignorance. The victim of this crime is ultimately Life itself. The viability of all life forms to survive in an increasingly contaminated environment is being eroded and will continue to erode throughout the generations until an end is brought to this villainy.

The accusations materializing across these pages are momentous. Where, it will be asked, is the proof?

Admittedly, within the public domain, no smoking gun exists for these crimes. There are no confessions from the principals involved, no documents unearthed revealing an international conspiracy. But it is the major thesis of this book that proof of this nature is not required. To know the Cult of Nuclearists and their crimes, all that is required is to look to their deeds. By their deeds you will know them. Left in the wake of their efforts to cover-up the radioactive pollution of the Earth is unmistakable evidence of their lies and deceptions.

Radiation protection, when applied to the public's exposure to nuclear/radiological weapons and the effluent from commercial nuclear reactors, is an elaborate show of smoke

and mirrors. It has been constructed to make an elephant, radioactive contamination of the Earth, disappear. Betraying the magicians' craft, secrets of the trade will now be revealed.

Contained within each new deck of cards are two jokers. In many types of card games, the rules allow for these jokers to take on changing identities for the benefit of those who hold them. In the game of radiation protection, these two jokers are *DOSE* and *RISK*. These are extremely slippery characters, chameleons, continually metamorphosing to lend the appearance to any radiation release that nothing hazardous to human health has transpired. When a radiation release occurs, the two most important pieces of information members of the public who might have been exposed want to know is their level of exposure (dose) and the risk this dose poses to their health. Clever manipulation of these two key pieces of information can transform any radiation insult, no matter how extreme, into a seemingly benign event.

Let's start unmasking the fraud by looking at the concept of dose. At its simplest, a dose of radiation represents a quantity of energy absorbed by the human body. As we saw earlier, the first unit of absorbed dose was the *rad*. It is calculated by dividing the total energy absorbed, measured in ergs, by the mass that absorbs it, measured in grams. Dose = energy *divided by* mass (d = e/m). According to current radiation protection guidelines, adults employed in industries where exposure to radiation may occur are permitted an annual dose of 5 rem (0.05 Sv). Members of the general public are permitted 0.1 rem (1 mSv) per year.

Now let's play a little game. Suppose, purely as a thought experiment, that the current system of radiation protection is not about protecting the public from the ill effects of radiation, but rather about protecting the nuclear establishment from criticism and covering up the casualties suffered by the public by the deeds of the Cult of Nuclearists. In order to insure that this racket continues indefinitely, doses to the public must be made to appear below the permissible dose. Given this prerequisite, how many ways can we manipulate the joker called dose so as to hoodwink a naive and trusting public into believing that they are safe from harm?

SCAM NUMBER ONE: According to the equation, dose = energy/mass, a dose of radiation can be reduced (and made to appear within the guidelines of safety) by increasing the mass that absorbs it.

One of the secret incantations recited by those charged with managing radioactive waste goes like this: *DILUTION is the SOLUTION to the POLLUTION*. An example of how

this maxim can be implemented to the benefit of the nuclear industry is illustrated by Karl Morgan in his book *The Angry Genie*. While employed at Oak Ridge during the 1940s, Morgan shared the responsibility of safely disposing of the radioactive waste generated as a byproduct of the nuclear weapons program. Broaching the subject with members of the Atomic Energy Commission, Morgan received a striking response: "Why not just dilute the radioactive waste to the occupational maximum permissible concentration, discharge it into White Oak Creek where it will seep into the Clinch River, and forget it?" (Morgan 1999) The implications of following this advice must be amplified. Regardless of whether or not the radioactivity being alluded to was diluted prior to discharge, the same quantity of radioactivity would be released into the waterway. Diluting it first, however, gives the appearance of being in compliance with legal statutes while not diluting it is a criminal violation. Presto! A magical way of transforming hazardous concentrations of radioactive waste into benign levels below regulatory concern. This is a routine method of complying with environmental regulation. For instance, hospitals, universities and research centers are permitted to routinely flush limited concentrations of low-level radioactive waste into sewers. By diluting the quantity of radiation in a volume of water, the perception is altered as to what is going on without actually changing the end result of how much radioactivity is being dumped into the environment.

This same sleight of hand has been applied to dosages received from internal emitters. In the United Kingdom, a major controversy has erupted concerning the health effects to the population from plutonium-239 released from the Sellafield nuclear fuel reprocessing facility. The Irish Sea is heavily contaminated with plutonium. Radioactivity is brought inland by sea spray and evidence exists that coastal communities are more heavily contaminated than those further inland. The winds also carry plutonium-laced effluent from Sellafield throughout much of the UK. Autopsies have confirmed that a proportional relationship exists between the amount of plutonium lodged in the tracheobronchial lymph nodes and how far the deceased lived from the facility (Popplewell). Further testifying to the extent of environmental contamination, plutonium has been detected in the feces of sheep grazing as far as 100 km from Sellafield and within the teeth of children living up to 200 km away. The plutonium escaping the plant primarily poses an inhalation hazard. Once deposited in the lungs, the insoluble particles of plutonium are available for scavenging by white blood cells which then ferry the pollutants to the tracheobronchial lymph nodes. *It is important to note that the combined mass of these tiny bodies of tissue is approximately* ***15 grams***.[10] (Inhaled particles of DU are likewise scavenged from the lungs and transported to the tracheobronchial lymph nodes.) In a contaminated individual, these lymph nodes can contain plutonium in concentrations between 100 to 10,000 times higher than in any

[10] The mass of the tracheobronchial lymph nodes in humans ranges between 10 and 30 grams. Average mass is 15 grams (Swinth, *et al.*).

other tissues of the body (Taylor; McKinroy *et al.*). Due to alpha emissions from the intensely radioactive plutonium, it can be assumed that a frighteningly high dosage of radiation is being deposited in these tiny tissue masses. As a consequence, there is an elevated risk for leukemia, induced by mutations to stem cells present within the nodes. As noted by Dr. Chris Busby: "Given that this organ [the tracheobronchial lymph nodes] has been identified as a source of lymphoma and leukemia in animals, this sounds very like the cause of the Sellafield leukemia cluster" (Busby 2001, Health Risks). For the nuclear establishment, such talk is heresy. If the public embraced the idea that pollution from a nuclear facility was causing leukemia, the weight of opinion might topple the government and force closure of Britain's nuclear program. The Cult of Nuclearists of that country cannot allow for such a possibility. As related by Busby (2003), the National Radiation Protection Board came to the rescue, armed with the prestidigitation of the corrupted computational system for calculating dosage. In NRPB R-276, *Risk of Leukemia and other Cancers in Seascale from All Sources of Radiation* (Simmonds *et al.*), plutonium dosage to the population was calculated by modeling the lymphatic system as consisting of a mass of **8,000 grams** that included the lymph nodes, liver, spleen, kidneys, pancreas, uterus, thymus, thyroid, stomach, both intestines, colon, red bone marrow, and cells on bone surfaces. The reader is challenged to find a single physiology book written anywhere in the world that offers such a definition for the "lymphatic system." Here, blatant criminality masquerading as science is indisputably apparent. In this publication, the dose actually deposited by plutonium to the tiny tracheobronchial lymph nodes is intentionally misrepresented as a dose to the whole "lymphatic system" following the conventional but sometimes questionable practice of stating exposure in terms of an organ dose. The lymphatic system, in turn, is modeled as consisting of a huge mass of tissue, a mass which for the most part is receiving no radiation. Only by this clever trick of mathematical dilution can the hazardous dose deposited in the tracheobronchial lymph nodes be made to appear as falling below regulatory concern as defined by the radiation protection community. While seriously contaminated people are becoming sick and dying from plutonium contamination, the National Radiation PROTECTION Board is covering up a public health tragedy with lies so as to run interference for that nation's nuclear programs.

SCAM NUMBER TWO: Rigidly adhere to the traditional concept of dose when evaluating the biological effects of radiation, even in instances where that concept of dose is rendered meaningless.

Earlier in this chapter, a description was given of how the science of radiation protection matured when the meaning of a dose of radiation was finally defined in terms of measurable and quantifiable phenomena. The rad represents a quantity of energy absorbed by a gram of matter. In keeping with many other concepts in physics, the rad is

an idealization, an abstraction, from physical events. Embodied within the concept is the assumption that the absorbed energy is evenly distributed (averaged) throughout the mass that absorbs it. This concept evolved from the study of x-rays and it accurately modeled the phenomenon *at relatively high dosages*. From an external source, a barrage of x-ray photons penetrates a mass and can be conceptualized as being uniformly distributed throughout that mass. Interacting with orbital electrons, the photons eject the electrons from their atoms. These liberated electrons create tracks of ionization through the material that, for all practical purposes, can be considered to cause uniform disturbance to the molecular makeup of the entire mass. This is a successful and powerful model. The degree of molecular disruption is directly proportional to the amount of energy absorbed. This has been experimentally validated in a wide range of applications and has become an extremely useful concept for predicating radiation effects. For instance, acute radiation syndrome is a medical condition initiated by dosages of approximately 100 rem (1 Sv) and above. The severity of the biological response to exposure and the course of the illness is directly related to the amount of radiation absorbed. The phenomenon has been so extensively studied that the likely outcome to a patient can be predicted on the basis of the absorbed dosage alone. The same holds true for cancer effects among exposed populations, again at relatively high doses. The number of cancers induced is directly proportional to the collective dose.

The success of this model demands a uniform distribution of energy throughout the mass that absorbs it. Conceptual problems arise within this model, however, when doses become so low that the entire mass is not uniformly disturbed. At this point the model breaks down. It no longer accurately describes what is taking place in the mass absorbing the radiation. To quote the European Committee on Radiation Risk, the energy units of rad and rem, gray and sievert "and the energy per unit volume approach are not applicable unless the system being irradiated is truly uniform. The model cannot deal with small volumes and inhomogeneities of dose, and for this reason, is unsafe to apply to internal irradiation."

To illustrate the problem, let us return to an example given earlier in the chapter. Busby explored the hypothetical situation of a single DU-containing particle, 2 microns in diameter, deposited in the lymphatic system. Using the ICRP method for calculating dosage, the amount of energy released by the particle in one year, considered as being evenly distributed throughout a lymphatic system defined as consisting of 800 grams, creates the insignificant dose of 0.0000021 rem (2.1×10^{-7} mSv). Now we have to ask ourselves, what is the actual meaning of this number? Is it really the case that if we were able to take a measurement at any point throughout the mass of the lymphatic system that we would get a reading of 0.0000021 rem? No, this is not true, because the actual energy of radioactive

decay is confined to the area around the point source of the single particle. Pure and simple, the purported organ dose in this instance is a mathematical fiction. It represents nothing in reality. It is a mathematical construction designed to create the erroneous idea that the energy of radiation emitted by the particle is uniformly distributed throughout the entire lymphatic system. But this is not the actuality of the situation. In reality, only a tiny volume of cells immediately surrounding the particle receives the entire dose. It is a major conceptual blunder to apply the traditional concept of dose to this dimension.

The shortcomings inherent in the concept of dose under these circumstances need no longer be an impediment to scientific accuracy. Advances in technology have given radiation biologists the power to witness, either directly or indirectly, radiation effects on both the cellular and molecular level. Microdosimetry allows for an accurate evaluation of the distribution of energy at this dimension of physical reality. And yet, radiation protection agencies rigidly adhere to the principle that the traditional concept of dosages to whole organs must be used to properly assess the biological impact of low levels of internal exposure. Why?

Because it deceives. Dosage, as misapplied to low levels of radiation, is a perfect instrument of camouflage, and is relied upon because it so successfully disguises the underlying biological effects. The successful model for calculating dosage and dose effects for high doses of external photon irradiation, by sleight of hand, is overlaid on a dimension of reality for which it doesn't apply. The science that supports the nuclear establishment forces this fit. It is the basis for the unfounded assumption, rigorously defended, that low-dose effects can be accurately extrapolated from verifiable high-dose effects. This abuse of the concept of dosage is one of the cornerstones of the conspiracy to mask the significance of low doses of radiation. It is an intentional misrepresentation of the phenomenon, upheld by the radiation protection community, to confuse people and distract intellectual inquiry into the safety of exposure to low levels of radiation.

As a front for the American war machine, a number of organizations have issued scientific opinions that uranium/depleted uranium weapons cannot possibly pose a radiological hazard to health. They base this claim on the fact that the *dose* uranium delivers to the lung is too small. They estimate the energy released by a hypothetical quantity of inhaled DU dust and average it over the mass of the lungs. Calculated in this way, the dose does appear insignificant, below regulatory concern. But let's shift paradigms for a moment. Let's dispense with the traditional concept of dose and view the contamination as a number of *discrete* alpha particles producing tracks of densely packed ionizing events that pass through the nuclei of nearby cells. All of a sudden, the shroud of deception created by the concept of dose drops away. On the cellular level, uranium/depleted uranium,

even in "insignificant" quantities, is clearly seen to be quite capable of producing double-strand breaks, mutation, genomic instability, and bystander effects. These are radiological hazards. The defenders of DU weapons innocently proclaim that these weapons pose absolutely no hazard to health because of the low doses they impart to tissue. This is nothing but a nasty deception, an out-and-out lie.

SCAM NUMBER THREE: Continue to calculate organ doses from internal emitters by averaging the emitted energy over the entire mass of the organ.

This is basically a rewording and summation of Scams One and Two. The work of the Tri-Partite Conferences and Subcommittee Two developed the method for calculating an organ dose from internal emitters by averaging the emitted energy over the mass of the organ. Deceivers use this science to mask the physiological impact of embedded hot particles. They dilute the emitted energy by smearing it over a mass of tissue, as in the Busby example above, and then declare how the dose is too low to be hazardous. *This is the centerpiece of the cover-up to forever assure that the medical effects of low levels of radiation produced by internal contamination will* ***never*** *be determined*. Earlier in this chapter, we cited the example of Dietz, who calculated that a particle of depleted uranium, 2.5 microns in diameter, transmits to the cells in its immediate vicinity in one year a dose of 170 rems. He concluded his article by saying, "until these doses can be related to a cancer risk factor, they must be viewed as qualitative indicators of danger, as red flags." This point unveils another element of this scam. The risk of developing a cancer from internal emitters is calculated from doses delivered to whole organs. The risk posed by localized point sources of hot particles has not been scientifically determined. Thus again, the assertion that uranium/depleted uranium weapons are without risk is premature and lacks scientific validation.

SCAM NUMBER FOUR: To ensure that the radiation protection community develops standards of safety acceptable to the nuclear establishment, make sure important staff appointments are filled by scientists sympathetic to the nuclear agenda.

The subject of "hot particles" dispensing huge quantities of radiation into small volumes of cells has haunted the nuclear establishment since the Manhattan Project. In the book *The Angry Genie* (Morgan and Peterson), Karl Morgan relates a telling anecdote of how the politicized radiation community dealt with this problem in the past:

> An early example of our profession's prostitution occurred with the 'hot particle problem' (HPP), which arose during the first five years of operations at the Hanford plutonium-producing facility (1944-49).

> Small radioactive particles released into the environment caused a substantial health risk to the surrounding population.
>
> Since the dose from a small, radioactively contaminated dust particle varies inversely as the square of the distance from the particle, simple calculation indicates that extremely high local tissue doses of thousands of roentgens will be received by the lung cells close to one of these small particles. Such large doses not only kill most of the cells close to one of these small particles but also cause surviving cells farther away to change into primordial cancer cells, the precursors of malignant tumors.
>
> These hot particles contained a mixture of radionuclides, such as Sr-90, Cs-134, Cs-137, Ru-106, and I-131, and undoubtedly some of the particles contained plutonium. Apparently no one conducted Pu-239 measurement at Hanford, but alpha measurements made elsewhere indicated large amounts of Pu-239, U-238, and U-235 on some of those particles.
>
> The AEC 'solved' the HPP when it formed an Advisory Committee of Competent Authority to investigate the matter.

After providing this background information, Morgan goes on to disclose how members of the committee for studying the HPP were chosen. A declassified letter is reproduced, originally written on September 25, 1962. It was authored by Paul Tompkins, deputy director of the Division of Radiation Protection Standards of the Federal Radiation Council. It was sent to Commissioner Haworth of the AEC. A portion of this letter reads as follows:

> Memorandum for Commissioner Haworth through Director of Regulation.
> Subject: Status Report on Current Activities of the Federal Radiation Council Working Group
>
> 1. It was agreed that current levels of radiation from fallout were too low to impose a practical problem in public health. It was suggested that the Public Health Service come up with its views as to what levels would correspond to enough of a health risk to justify diversion of resources in order to provide protection. If any reasonable agreement on this subject can be reached among the agencies, the basic approach to the report would be to start with a simple, straightforward statement of conclusions. We would then identify the major questions that

> could be expected to be asked in connection with these conclusions. It would then be a straightforward matter to select the key scientific consultants whose opinions should be sought in order to substantiate the validity of the conclusions or recommend appropriate modifications [italics added].

Bluntly stated, this is an ass-backward method of doing science. Start with the conclusions you want to arrive at. Determine the questions that may arise when putting forth these conclusions. Then acquire "scientific confirmation" of your predetermined conclusions by enlisting support from scientists sympathetic to your political agenda. This stain on the scientific enterprise is sobering. It testifies that science as a purely objective path for disclosing the nature of physical reality is a myth.

Morgan continues:

> The Advisory Committee proclaimed that the HPP presented no problem after all. In reaching this conclusion, they accepted the meager data they could find that supported what I believe was their foregone conclusion.
>
> The Advisory Committee disregarded early studies of high incidence of in-situ tumors when Sr-89, Sr-90, Y-91, Ce-144, Ra-226, and Pu-239 were injected subcutaneously or intramuscularly into mice, rats, and rabbits, such as the results reported by H. Lisco *et al.* in 1946 (Lisco *et al.*). Minute amounts of plutonium produced cancers at the site of injection and bone tumors occurred frequently in mice, rats, and rabbits injected with plutonium at levels ranging from 0.05 to 5 millionths of a curie per gram of injection — the majority of the plutonium-induced tumors occurring in the spine. One microgram of Pu-239 (0.061 microcurie) injected locally under the skin would induce fibrosarcomas even though much of the injection dispersed from the site. This frightening and sobering news caused us to increase our efforts to reduce plutonium exposure, but the decision of the advisory committee still stood: the HPP did not exist.
>
> For the cause of justice, the HPP cannot be covered up. Hundreds of thousands of years will pass before all the evidence can be destroyed. Some of these particles remain in attic heating ducts and furnaces. Some are certainly in the remains of those unfortunates who unknowingly inhaled these radioactively contaminated dust particles. These hot particles will remain in geologic formations for millennia, where future generations of scientists may obtain evidence on the foolhardiness

of their ancestors.

Stacking different scientific committees with the same people is a way of giving the impression that a broader consensus exists on a particular issue than actually is the case. This gimmick has been put to good effect by those organizations which have issued reports on the harmlessness of depleted uranium. Keith Baverstock substantiated this fact in June of 2005 during a presentation to the European Parliament:

> A number of organizations, including the World Health Organization, the International Atomic Energy Agency, the UK Royal Society, the International Commission on Radiological Protection and the European Commission Article 31 Group have, since 2001, published advice relating to the health consequences of exposure to DU. You may wonder, as I do, how such authoritative and independent organizations, making ostensibly "independent" assessments of the situation can all ignore the evidence that exists in the scientific literature.
>
> It is worth noting that these assessments may not in fact be truly independent. For example, staff of the UK National Radiological Protection Board (NRPB) are acknowledged as contributing to the WHO and RS reports, the Chairman of the ICRP was recently the Director of the NRPB. Staff members of the NRPB collaborate with the IAEA and have been members of the Article 31 Group. It is, therefore, possible that a few individuals have influenced the outcome of these so called independent assessments (Baverstock).

SCAM NUMBER FIVE: In the aftermath of a radiation release into the environment, the perception of hazard to the exposed population can be managed by controlling information of the quantity of radiation involved, and thus, the dosages.

Returning to our simple equation of dose = energy/mass, it is readily observed that dose can be made to appear smaller by reducing the amount of energy involved. The energy emitted by radioactive atoms is a known physical quantity. If you know which radioisotopes are released in an event and in what quantities, you know their manner of radioactive decay, their half-life, the amount of energy emitted by each decaying atom, and so forth. This knowledge can be combined to derive estimates of the maximum dose to the entire exposed population. Under these circumstances, the only way to manipulate knowledge of the dose people may have received is to control knowledge of the total amount of radioactivity actually released. If you are in a position to do this, no one will be able to

accurately assess the doses received, whether these doses are within the range deemed "permissible," and what illnesses appearing later in the population might be attributable to radiation exposure. Examples of this scam are too numerous to mention here within these pages. Repeatedly over the decades has long-suppressed information come to light of once-secret radiation releases from such nuclear installations as Sellafield in the UK, the Chelyabinsk-40 complex in the USSR, and in the US at the Hanford Reservation in Washington State, Rocky Flats in Colorado, the Savannah River Plant in South Carolina, the now-closed Feed Materials Production Center in Fernald, Ohio, and the nuclear facilities in Paducah, Kentucky.

This scam was the major tool involved in covering up the commercial nuclear reactor accident in 1979 at Three Mile Island. To this day, the public has been denied access to accurate information on what radionuclides were released and in what quantities. Without this key piece of information, "dose" to members of the exposed population is incalculable. The number of people made sick by the event, the number of people that will die because of the event, can never be gauged as long as information on dosage is manipulated or withheld. This protects the nuclear establishment from culpability and ensures ongoing support for the wide range of nuclear programs. The big losers at Three Mile Island were those dwelling downwind of the event. With no knowledge of the dosages they may have received, they are unable to assess the risk they incurred to their health. Their lives are forever haunted by the prospect of radiation-induced cancer waiting to ambush them 25 to 40 years down the road. If disease strikes, their anguish may be intensified by not knowing the reason. People ask, "Why is this happening to me?" Victimization is hard to bear, particularly when it robs you of your health and shortens your life. Cover-ups of radiation accidents carry in their wake many different types of human misery.

Three Mile Island was not an isolated event. The catastrophe at Chernobyl in 1986 was variously reported by different organizations with diverse interests in nuclear technology. These reports differed by their estimates as to how much radioactivity was released from the destroyed reactor core. At the time of the accident, the core contained approximately 192 tons of radioactive material consisting of approximately nine billion curies of radioactivity. In the immediate aftermath of the event, the Soviet government declared that 50 million curies of radionuclides and 50 million curies of chemically inert radioactive gases escaped into the biosphere. This overly conservative estimate was challenged from many quarters. The Nuclear Agency Committee of the Organization for Economic Cooperation and Development estimated that the maximum release from a group of the 20 most important radionuclides totaled 340 million curies. Estimates made at the Argonne National Laboratory in the United States suggested that 30% of the core's radioactivity, nearly three billion curies were released in the accident. The Lawrence Livermore National

Laboratory's estimate was even higher, suggesting that half of the core's radioactivity, 4.5 billion curies, were spewed out of the breached reactor. Finally, Vladimir Chernousenko, Scientific Director of the Ukrainian Academy of Sciences Institute of Physics in Kiev's Task Force for the Rectification of the Consequences of the Chernobyl Accident published an estimate that fully 80% of the core's contents were liberated into the environment (Chernousenko). These varying estimates are not just of academic interest. Each represents a political statement. Each implicitly carries a statement of the possible health effects that will be distributed throughout the contaminated populations. What is the true health legacy of Chernobyl? No one really knows. The lethality of the accident can only be gauged on the basis of the quantity of radioactivity liberated. The uncertainty of this critical piece of information renders all estimates questionable.

When one reviews the history of radiation accidents, one repeatedly discovers that the public has been kept in ignorance of the potential medical impact from events because they have been denied access to knowledge of the quantity of radioactivity released into populations. Operating under the veil of national security, governments can escape accountability for their deeds. How many tragedies have been covered up? How much radiation was released by the weapons labs of the nation? How much radiation has been released by commercial nuclear reactors? How much radioactivity has escaped into the environment? If you control this information, you control the thinking of the people. You cover up medical effects by covering up dosage.

Again, the discussion comes around to uranium weapons. The United States currently pursues a policy of preventing information of its weapon systems from reaching the public domain. No one knows how many types of weapons contain uranium, how much uranium is contained in each weapon, and the tonnage of weapons discharged in each campaign. This cover-up serves an important political purpose. *It prevents dosages of radioactivity from being calculated*. If an Afghan family lives immediately downwind of a building destroyed by a bomb containing 1,000 pounds of uranium, and if they inhale aerosolized uranium dust from the plume, their radiation dosage may be medically significant. It is fraudulent science, hocus pocus mumbo-jumbo, to sell the world on the corrupt idea that uranium weapons are not radiological weapons, and these weapons are not capable of producing indiscriminate health effects. The United States of America is perpetrating crimes against humanity and covering up its deeds by covering up the radiation dosages of its victims.

SCAM NUMBER SIX: Beguile the public with inappropriate comparisons between external irradiation and internal contamination.

The proliferation of nuclear weapons and commercial nuclear power plants has succeeded in deluding the public of the hazards of internal contamination. Covering up the danger of radioactivity within the body from human-generated radioisotopes is the bedrock upon which the entire nuclear behemoth is secured. A common tactic used to dupe critical thinking on issues of radiation safety is to liken the *dose* received from internal emitters to the *dose* received by natural background radiation. This is very sophisticated flimflam. To the uninformed, it appears perfectly logical that dose is dose; regardless of how the energy is delivered to the body, the end result will be the same. If we receive small doses of radiation naturally just from dwelling on planet Earth or while flying in an airplane, and if these are harmless, it seems quite reasonable to conclude that the same doses delivered by internal emitters will likewise be inconsequential. By now the reader knows the con hidden within this line of thinking. It was extensively explored in Exhibit A. The biological effect of a dose of radiation depends totally on how that dose is delivered to the body. By natural background radiation, ionizing events are widely distributed both in space and time throughout the mass of the body. By contrast, internal emitters have the capacity of repeatedly hitting the same cellular structures within a small volume of tissue. In instances where "doses" are comparable, the hazard posed by internal emitters will be greatly enhanced.

This swindle can be found in the literature penned to defend the harmlessness of uranium weapons. Claims are made that the dose from inhaled uranium is as insignificant as natural background radiation. Left unsaid is that the dose from uranium/depleted uranium weapons is delivered by densely ionizing alpha radiation to sensitive and critical components of a small volume of cells, while natural background radiation is deposited throughout the whole body. Research has confirmed that, like plutonium, a portion of depleted uranium deposited in the lung is scavenged by white blood cells and transported to the tracheobronchial lymph nodes. These tiny structures become the repositories of concentrated quantities of DU. This localization of dose poses an elevated hazard to the organism that is simply not comparable to the same dose delivered to the whole body by natural background radiation.

SCAM NUMBER SEVEN: Following a radiation release, avoid conducting adequate radiation monitoring.

First-year students of philosophy are invariably presented with this classic dilemma to ponder: If a tree falls in the forest and there is no one there to hear it, does it make a sound? An analogous conundrum is routinely posed by the Cult of Nuclearists: If radiation is released into the environment and no one is there to measure it, does a hazard exist? They would like the world to believe that the answer is no, no hazard exists. Each radia-

tion release and its health consequences evaporate when no adequate radiation-monitoring data testifies to the event. No causality can ever be established between radiation and illness if exposed individuals have no information on the doses of radiation they have received. Most people suppose that radiation monitoring of the population and the environment is carried out with diligence. This is an unwarranted assumption. As Caufield observes,

> Monitoring radiation in the environment and in humans is, in fact, so difficult that it is rarely done. Many people assume that radioactive releases are closely monitored and that government agencies know the radiation exposure of the local soil, water, plants, animals, and people. This is not the case. Some, but by no means all, radiation users are required to continuously monitor their own routine releases for gamma — through rarely for alpha — emissions. Water, soil, and food, however, are checked only sporadically and usually only for gamma radiation. Members of the public are not monitored for radiation exposure because of the expense, the inconvenience, and the fear that such monitoring would cause alarm.

Radiation released into the environment poses a challenging problem to public health. Once liberated from its source, radioactivity most often migrates in the form of individual atoms or small particles. The pathways that these particles follow are determined by environmental forces working in concert with natural chemical processes. The fate of this radiation and the biological effects it produces remain unknown until scrutinized by meticulous scientific investigation. If this research is not undertaken, the perfect crime has been committed. Forensic investigation falters when there is no weapon and no body. So daunting is the problem posed by radioactive atoms freely dispersed around the planet that science has yet to evolve to the level of sophistication necessary to assess the full spectrum of biological effects that mankind's nuclear experiment has produced. What the general public fails to appreciate is that the determination of levels of internal contamination is most often a costly, labor-intensive undertaking frequently requiring sophisticated detection equipment. The popular image in the public mind is of a radiation-safety officer dressed head to toe in protective clothing, a breathing apparatus strapped to his back, carrying a geiger-mueller counter that he swipes back and forth as he moves through the environment. This type of monitoring provides information about radiation in the environment. But it provides only indirect information about the potential hazards of internal contamination to those potentially exposed. Measurements of the actual levels of alpha and beta emitters trapped within a human body cannot be done by simply running a handheld detector over the body's external surface. Given the limits of the technology, internal contamination, except in instances of acute exposure, is rarely performed. As a substitute for

this, mathematical modeling is performed, based on environmental data, to provide estimates of probable dosages of those potentially exposed. Estimates? Probable? Potentially? Another dirty little secret of the Nuclear Age scurries out from the shadows. With widespread monitoring of internal contamination not possible, knowledge of the fate of radionuclides liberated into the environment and their ultimate biological impact as it pertains to human health is simply not known. Average levels of contamination absorbed by humans can be estimated, but these may fail to take into account anomalous situations which result in individuals accumulating medically significant levels of contamination. When radiation escapes into the environment, it is not always uniformly distributed. Modeling the distribution of escaped radioactivity and possible patterns of uptake by humans may not accurately reflect the reality of what is taking place. Radioactivity can accumulate in unidentified hotspots. Animals used as food may accumulate environmentally dispersed radioactivity in their tissues at unexpected levels that may be hazardous. People's patterns of consumption of contaminated food and water varies. People vary in the multiple exposures they receive from the full gamut of radiation-emitting sources. Formulating estimates of the "average" dosage for members making up a population can mask elevated and hazardous exposure to particular individuals. What we are doing to ourselves and to our planet is not known with sufficient precision to conclude that all is well.

The Cult of Nuclearists in the United Kingdom claims that plutonium released from the nuclear reprocessing plant at Sellafield is medically insignificant. The Pentagon declares that depleted uranium released amidst populations is harmless. Such claims are scientifically baseless. Unless dosages are measured for the entire exposed population, unconditional affirmations of safety of all those exposed are not credible. The alternative is to speak the truth. But this would entail admitting that some amongst us are being made sick and are dying from nuclear pollution.

The AEC successfully misled the nation on the health hazards emanating from the Nevada Test Site by not conducting adequate radiation monitoring. Who amongst the population were exposed and the dosages they received will remain forever unknown. These people make up an invisible cohort of silent victims, casualties of the Nuclear Age. This cohort is filled by other faceless victims as well. What was the fate of the sport-fisherman vacationing in Washington State who consumed gluttonous quantities of salmon drawn from the Columbia River, a river heavily contaminated by high-level radioactive waste discharged from the Hanford Reservation?[11] How much strontium-90 and cesium-137 did you or your parents ingest through the consumption of contaminated beef and dairy products during the era of aboveground weapon testing or after Chernobyl? How much depleted uranium did your son actually inhale during Operation Desert Storm?

[11] The Hanford Reservation in Richland, Washington was originally constructed to produce plutoni-

Estimates of dosage float around for these events, but really, they are nothing but guesses. They represent averages based on a number on unverified assumptions. Without precise monitoring of these seemingly innocuous events, ignorance prevails as to who the real victims of a radiation accident are. This suits the Cult of Nuclearists just fine.

The United States, with impunity, bombs foreign populations with uranium weapons and disguises its misdeeds by not monitoring radiation levels in the environment or within the bodies of contaminated victims. This casts a veil over the entire enterprise. Uranium/depleted uranium is deemed harmless because no efforts are being made to find out anything further about its effects. It falls to independent investigators to unearth the smoking gun. As this is being written, news is leaking out of Iraq that, in areas of downtown Baghdad, radiation has been measured at 1,000 times background levels. Why? How did that radiation get there? Who has been exposed? What were their dosages? Has anyone become ill? To these questions, no answers are forthcoming. A perfect crime.

SCAM NUMBER EIGHT: In instances where environmental monitoring is undertaken, avoid measuring the full spectrum of radiation emitted from the radioisotopes involved.

This scam has been repeatedly relied upon throughout the nuclear age to minimize the perception of hazard created in the aftermath of major radiation releases. As outlined in Exhibit C, the study of the survivors of Hiroshima has been fabricated as a study of exposure to external gamma irradiation. Conveniently overlooked is the internal contamination incurred by both the study and control populations which hopelessly obscures any relevant conclusions of risk borne by those directly exposed to the blast. The same cover-up occurred with contamination drifting from the Nevada Test Site. The AEC monitored gamma emissions from fallout and attempted to sell to the public the idea that this was where the only hazard resided. Only grudgingly, when cornered by independent scientists,

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um for the Manhattan Project and was a major production facility for nuclear material after the War. Today, 50 million gallons of high level liquid are stored underground in 177 storage tanks. In addition, the site is home to 2,300 tones of spent nuclear fuel, twelve tons of plutonium in various forms, 25 million cubic feet of buried or stored solid waste, and about 270 billion gallons of groundwater contaminated above drinking water standards.

In 2005, the Government Accountability Project and Boston Chemical Data Corporation released a study on contamination of the Columbia River. This study provided the first solid evidence of plutonium contamination in fish. Aquatic creatures were also found to be contaminated with elevated levels of strontium, mercury, beryllium, uranium and cesium.

The study also published data on strontium-90 contamination of mulberry plants offering proof that contaminated groundwater was being transfered into the biosphere. Rodent droppings bore evidence of a 13-fold increase in strontium-90 over similar specimens found downstream of Hanford. This provided direct evidence of strontium-90 contamination in the food chain of higher organisms.

did the AEC reluctantly admit that radioactive iodine was a hazard to thyroid health and childhood development and that dose reconstruction of this radionuclide to the downwind population was warranted. Often overlooked is the fact that the detonation of a nuclear weapon produces over 400 different radioisotopes. Many of these are extremely short-lived and many are biologically insignificant. Nevertheless, a complex of radioactive molecules created out of dozens of medium and long-lived radionuclides can assault health in ways that are not yet completely understood. Further, these may act synergistically to produce effects not anticipated when each radionuclide is modeled independently.

Currently, this scam is being used very effectively to minimize the perception of the health toll from the accident at Chernobyl. If one scours the literature on the aftermath of Chernobyl, the persistent investigator will find little information on adverse health effects from the accident other than thyroid disease and thyroid cancer. The nuclear establishment has reluctantly been forced to admit these types of pathologies result from nuclear pollution. Thyroid disease, induced by radioactive iodine, is relatively uncommon, easy to detect, and appears within a relatively short time after radiation exposure. Children are the most vulnerable, and increased incidence of thyroid abnormalities stand out in glaring relief in a population exposed to fission products. These illnesses cannot be made to disappear. But again, what of the medical impact of the other biologically significant radioisotopes? These are being passed over in silence. They are treated as if they don't exist and don't pose a detriment to health. Sufficient time has yet to pass before an epidemic of radiation-induced tumors and other diseases will begin to appear. Evidence of this is present in data collected by the national cancer registry of Belarus. According to the database of malignant tumors maintained at the Clinical Institute of Radiation Medicine and Endocrinology Research in Minsk, cancer incidence between 1990 and 2000 rose 40% over the incident rate prior to the Chernobyl disaster (Okeanov *et al.*). And this alarming trend is emerging just 18 years after the accident. Although organizations aligned with the Cult of Nuclearists are working overtime to deny it, other radioisotopes besides those of iodine are producing an epidemic of malignancies in addition to the epidemic of thyroid cancer.

Sometimes, learning of the blatant cronyism that prevails among nuclear apologists can make a person embarrassed to be a human being. That was the response of this author when reading in September 2005 of a newly published study entitled "Chernobyl's Legacy: Health, Environmental and Socio-Economic Impacts."" The three-volume, 600-page report was written by the Chernobyl Forum, a committee comprised of representatives of the International Atomic Energy Agency, World Health Organization, United Nations Development Program, Food and Agriculture Organization, United Nations Environment Program, United Nations Office for the Coordination of Humanitarian Affairs, United Nations Scientific Committee on the Effects of Atomic Radiation, and the World Bank, as

well as the governments of Belarus, the Russian Federation and Ukraine. Posturing as the new voice of authority on the Chernobyl accident, this coterie united behind the conclusion that the number of deaths that could be directly attributed to radiation was a mere 56. Of these, nine children died from thyroid cancer. The remaining victims, rescue workers who spent time in the immediate vicinity of the destroyed reactor, died from acute radiation syndrome. This death toll was in stark contradiction to previously published figures from the Ukraine where 4,400 deaths had been registered as attributable to radiation exposure. As reported by the Associated Press, the chairman of the Chernobyl Forum, Dr. Burton Bennet, said: "previous death tolls were inflated, perhaps 'to attract attention to the accident, to attract sympathy.' He said the majority of workers and residents around the plant received low doses of radiation, and that poverty and 'lifestyle diseases' posed a 'far greater threat' to local communities" (Loof). Countering previous predictions that the number of deaths caused by Chernobyl would climb to tens of thousands, the Forum concluded that the upper limit would reach no more than 4,000. These deaths would be from cancer and leukemia among the population of 200,000 emergency workers, 116,000 evacuees and 270,000 residents in the most contaminated areas. The total number of children that would eventually develop thyroid cancer was estimated at 4,000. A fitting response to conclusions of the Chernobyl Forum was made by Oleh Andreev, spokesman for the Ukraine Emergency Situations Ministry: "The one who says the devil is not as black as he is painted had better live here and see the problem from the inside" (Loof).

The conclusions of the Chernobyl Forum are comedic skullduggery, brought to you by representatives of the same organizations that proclaim that depleted uranium in the environment is harmless. It is meant to whitewash the hazard to health of low levels of radionuclides. In rebuttal, the reader is referred to an article by Alexey V. Yablokov entitled "The Chernobyl Catastrophe - 20 Years After (a meta-review)." This article contains an extensive review of Russian research into the health effects produced by the accident. Among the data presented are a number of statistics that put the conclusions of the Chernobyl Forum to shame:

> - Since 1986, there has been an increase in general mortality in the radioactively polluted areas of Ukraine, Belarus and Russia in comparison to neighboring areas (Grodzinsky 1999; Omerlianetz *et al.*, 2001; Kashirina 2005; Sergeeva *et al.*, 2005).
>
> - A correlation exists between an increase in the number of stillbirths and the amount of radioactive pollution in the environment in some areas of Belarus (Kulakov *et al.*, 1993) and Ukraine (Golovko and Izhevsky 1996).
>
> - In some European countries, a correlation was revealed between

perinatal mortality rates and the Chernobyl meltdown (Korblein 2006).

- In the polluted areas of Ukraine (Omelianetz and Klement'eva 2001) and Russia (Utka *et al.*, 2005), an increase in infant and children's mortality was documented.

- Between 1987 and 1995 in the polluted areas of Belarus, there was an increase in the number of newborns who died with central nervous system congenital malformations (Dzykovich 1996).

- Between 1990 and 2000, the rate of cancer increased forty percent in Belarus. The increased incidence of cancer in different territories of the country was in direct proportion to the level of radioactivity measured in the environment of each territory (Okeanov *et al.*, 2004).

- The number of radiation-induced thyroid cancers recorded in Belarus alone totaled 4,400. The combined incidence rate for thyroid cancer in Belarus, Ukraine and Russia through 2001 was roughly 12,000 cases (Imanaka 2002). These numbers are expected to substantially increase over the next forty to fifty years.

- There is increased frequency of leukemia in all the polluted areas of Ukraine, Belarus and Russia (Prysyazhnyuk *et al.*, 1999; Ivanov *et al.*, 1996; UNSCEAR 2000).

- Among 32,000 people evacuated in Belarus, the incidence of lung cancer was four times greater than the national average (Marples 1996).

- Yablokov provides extensive documentation, citing scores of studies, that demonstrate a general overall decline in health among people from the contaminated territories when compared to pre-accident levels or when compared to populations not contaminated by Chernobyl fallout.

The medical effects from Chernobyl were not confined to the areas in immediate proximity to the stricken reactor. As an example, fallout from the accident produced congenital defects in babies born in Germany:

A recent study by a team of scientists from the official childhood can-

> cer registry in Mainz, Germany, reported a statistically significant increase in a very rare kind of tumor of the nerve cells in young children (neuroblastoma) for babies born in 1988, 2 years after the explosion of the Chernobyl reactor (Haaf *et al.*). For the 1988 birth cohort, in areas with more than 10^4 Bq/m^2 cesium-137 soil contamination, the number of cases recorded until mid-1992 was 1.96 times the expected number for Germany during the years 1980-1987 (22.5 cases per 10^6 live births); for areas with 6 x 10^3-10^4 Bq/m^2 contamination, the number of cases was 1.65 the expected number, and for areas with less than 6 x 10^3 Bq/m^2 radioactive cesium deposition the ratio was 0.98. Similar increases in neuroblastoma rates were found for babies born for the years after 1988. Given the clear association of relative risk for a rare congenital defect with levels of radioactive cesium contamination, a causal relationship is likely (Nussbaum and Kohnlein).

SCAM NUMBER NINE: Let the fox guard the henhouse; leave radiation monitoring and dose reconstruction in the hands of those who have a vested interest in minimizing the perception of hazard.

This scam recurs every time radiation is released into the environment. A clear, documented example from recent history will suffice to expose the deviousness at work when the government takes responsibility for determining dosages and their medical consequences. In 1979, during the Carter administration, a radiation study was undertaken by the Task Force on Compensation for Radiation-Related Illnesses. The purpose of this study was to explore the feasibility of compensating radiation victims living downwind of the Nevada Test Site. The Task Force was comprised of 13 members, six from the Departments of Energy and Defense, with the others drawn from the Veterans Administrations and from the Departments of Justice and Health. In their final report, they estimated that, within the 250 mile radius of the test site, 170,000 people received radiation exposure. Using the "available monitoring data," they "estimated" that

> "19 people had been exposed to more than 5 rems, 10,817 persons had been exposed to between 1 and 5 rems, and the remainder had received less than 1 rem."

> "Using dose-response statistics published in the controversial 1979 draft report of the National Academy of Science's Committee on the Biological Effects of Ionizing Radiation (the BEIR III report), the task force estimated that between 18 and 48 cancers above the expected

> number might occur, of which from 6 to 18 could be fatal. Applying an uncertainty factor of 2, the number of such cases could be as high as from 36 to 96, of which from 12 to 32 might be lethal. 'Thus, from an overall public health perspective,' the report stated, 'the added risk to the downwind population from fallout was very small'" (Fradkin).

By this time, the reader should be able to spot some of the elements of the game being played by poker-faced representatives of government. Monitoring data throughout the whole period was inadequate. Dose estimates were based entirely on external gamma irradiation. The medical impact of internal contamination by fission products was conveniently swept under the table and made to disappear from the mind of the casual reader not versed in issues of radiation. Missing entirely from the report was any mention of thyroid doses, knowledge that had been assembled thirteen years earlier by Gofman and Tamplin in *Estimation of Dosage to Thyroids of Children in the US From Nuclear Tests Conducted in Nevada During 1952 Through 1957*. In that report, the estimated dosages to the thyroid glands of children living in cities within 250 miles of the test site included St. George, 120 rads; Roswell, New Mexico, 57 rads; Salt Lake City, 46 rads (Fradkin). Only by ignoring the available evidence could the task force conclude: "*Thus, from an overall public health perspective, the added risk to the downwind population from fallout was very small.*"

In contrast to this politicized attempt to sanitize the misdeeds of the government, the National Cancer Institute published an interesting study in 1997. The study attempted to come up with a reasonable estimate of the number of cancers induced in the population from weapon testing from *internal contamination* by a **single** fission product, iodine-131. It's important to emphasize that only this one isotope was considered. Left out of consideration were the cancers induced by internally incorporated isotopes of strontium, cesium, plutonium, and the other radionuclides meriting attention. Their conclusion was sobering. They estimated that 150 million curies of iodine-131 were scattered over the United States in doses large enough to produce 10 to 75,000 cases of thyroid cancer, with 10% of these being fatal.

SCAM NUMBER TEN: Focus attention on dosage as the prime determiner of biological effect so as to divert thought from pioneering an appreciation of the biochemical chaos induced by the transmutation of atoms during radioactive decay.

Within the context of the reigning paradigm, radiation injury is proportional to the amount of energy absorbed by the body. Consequently, internal emitters that are widely dispersed throughout the body and which release small quantities of energy are deemed

inconsequential to the health of the organism. *The fallacy lurking in this line of thought is that certain radioisotopes can promote biological effects as a consequence of their chemistry that is independent of the amount of energy they release at the moment of radioactive decay*. The Low Level Radiation Campaign highlights this phenomenon on its website in an article on tritium.

Tritium is an isotope of hydrogen; its one proton shares the nucleus with two neutrons. Its half-life is 12.3 years. At the moment of radioactive decay, each atom of tritium transforms into an atom of helium while emitting a beta particle with an average energy of 5.7 thousand electron volts (keV.) Tritium is ubiquitous in the environment. It occurs naturally in very low concentrations, produced in the upper atmosphere by the interaction of cosmic rays with either nitrogen or deuterium in the air. It then falls to the ground as rain. Tritium is also produced in the fireball of nuclear weapons, and the earth's burden of tritium was substantially increased as a result of nuclear weapon testing. Commercial nuclear power plants produce tritium within their reactors, and this is routinely vented into the ecosphere. Tritium is found in nature as a gas and can gain entrance to the human body through the air we breathe. It can also be readily absorbed through the skin. More commonly, a tritium atom will replace a stable hydrogen atom in a molecule of water, and this tritiated water will then gain entrance into the interior of the body. Once internalized, tritium disperses quickly and is uniformly distributed throughout the body. The biological half-life of tritium is 9.4 days. However, residency time can be greatly extended to a number of years if, chemically bound into the structure of organic compounds, tritium enters the body via ingested foodstuffs.

Due to its uniform distribution throughout the body, the weakness of its emitted beta particle, its relatively long half-life and short biological half-life, tritium is considered, under normal levels of intake, to pose an insignificant health risk. The "dose" of radiation it transfers to any organ or to the body as a whole is too minute to be of much concern. This conclusion is hazardously deceptive. It would be true if the total energy absorbed by the body was the sole determiner of biological effect, but for at least some biologically significant isotopes, this notion woefully misrepresents what actually is transpiring on the molecular level.

Having gained entrance into the body, tritium, chemically identical to hydrogen, can become incorporated into the structure of essential biochemicals such as enzymes, proteins, RNA and DNA. Tritium can also participate in forming hydrogen bonds between molecules. Once incorporated into molecular structure, tritium behaves no differently from stable hydrogen until the instant of radioactive decay. At that moment, all bonds between the tritium atom and the atoms that bond to it are broken. Inert helium replaces the hydrogen atom and dissociates from all adjacent atoms. The result of this transmutation is chemical

chaos. Those atoms that were previously bonded to tritium become highly reactive and randomly reattach to available atoms in their vicinity. What started out as an ordered biological macromolecule is transformed into molecular garbage that may be useless, perhaps even toxic, to normal cellular physiology. In the case of enzymes and proteins, their spatial configuration can become so distorted that they stop functioning altogether or, perhaps worse, malfunction. In the case of DNA, an intricate series of events may be initiated with ramifications all out of proportion to the amount of radiation involved. At the moment of disintegration, the loss of the hydrogen atom may be responsible for significant damage to DNA structure. Simultaneously, the ejection of the low-energy beta particle may compound the damage with further ionizing events in the immediate vicinity. What is important to recognize is that the transmutation of a single tritium atom within a molecule consisting of thousands of other atoms represents a tremendous amplification of effect. A single radioactive disintegration can render an entire macromolecule useless. Occurring in DNA, it may contribute to genetic damage. Occurring within the embryo, developmental abnormalities may be induced. All of a sudden, innocent tritium doesn't look so innocent.

Transmutation is not confined to radioactive hydrogen. It can result from the disintegration of any radioisotope bound within organic molecules. It enhances the damage to an organism's biochemical structure and function produced by radiation. Those who chime in with the observation that this is a commonplace phenomenon occurring from naturally present radioisotopes in the environment and that cells are forced to manage molecular rubbish all the time fail to give transmutation the importance it deserves. The biochemical dance of life is not understood with sufficient precision. Perhaps transmutation that occurs at precise moments during common physiological processes, such as during DNA replication, will have amplified effect than when occurring at other moments. Perhaps increasing the body burden of radioisotopes throughout the world's population increases the frequency of certain genetically based diseases. Once again, we are at a loss to fully understand what we are doing to ourselves and all life forms by dumping radioisotopes into the biosphere and into ourselves in unnatural quantities.

SCAM NUMBER ELEVEN: Rely on the concept of "dose" to mislead the layman about the biological impact of low levels of radiation.

In Exhibit A, a pivotal issue was raised that requires reiteration. In *Radiation Protection Dosimetry*, Simmons and Watt make the following point: "The amount of kinetic energy transferred in each collision plays no role in the production of radiation effects in mammalian cells." To clarify this point by way of example, to irreparably disrupt the structural integrity of a DNA molecule in the nucleus of a cell nothing more is required than the addition of sufficient energy to produce simultaneous, or near-simultaneous, ionizing events

on each strand of the double helix, i.e., a double-strand break. The amount of energy needed to accomplish this may amount to no more than a few tens of electron-volts. Any additional energy to that required to break the two chemical bonds is irrelevant to the lesions produced. This simple idealization pinpoints the deceptiveness of the concept of dosage. The amount of energy absorbed by a mass of cells, the dose, is not what determines biological effect. Rather, biological effect is determined by the spatial concentration of ionizing events in relation to critical molecular components within each cell that is hit. From this point of view, the essential characteristic is "passage of particles per unit volume" or "hits per unit mass."

It is not difficult to see the importance of this shift in perspective when addressing the hazard posed by radiation exposure to the developing fetus. While in the womb, a catastrophic effect on the future health of the human being can potentially be induced by a single alteration to a DNA molecule. This modification is independent of the dose. Thus, extremely minute quantities of radiocontaminants in the vicinity of germ cells prior to conception or in the womb after conception can devastate a human life. (Thus, the discovery of depleted uranium in the semen of Gulf War Veterans is an alarming discovery!) **The genetic mutation induced by radiation need not manifest itself after birth as a visibly deformed child or a child plagued by debilitating illness.** (Such visible effects are the criteria for genetic defects produced by radiation used by the Hiroshima Life Span Study.) The altered cell, and all of its descendants, may be transformed into precursor cells of cancer, more vulnerable than unaffected cells to being tripped into uncontrolled cell replication by other random events at some future time in the person's life. As observed by the ECRR:

> In the event that an irradiated cell is altered rather than killed, the outcome is very different. Despite the existence of cell repair mechanisms and, in the whole organism, further surveillance systems for the elimination of such cells, the clone of cells which carry the modification induced by the radiation will have a higher probability than the original cell of acquiring the set of genetic changes necessary to cause uncontrolled replication. This may result in the manifestation of a malignant condition, a cancer. It may also result in a detrimental effect on the efficiency of the organ or system which the cell is a part of, with resultant ill health in the individual (ECRR).
>
> [Thus, cancer need not be the only health detriment produced by radiation!]

If "dose" is to have any meaning at low levels of exposure, the inaccurate concept of a quantity of energy averaged over a large volume of cells must be discarded. In its

place, the concept of dose must come to be seen as representing a probability of the number of particle tracks passing through cells within a specified volume and the likelihood that these will produce significant, irreparable lesions such as double-strand breaks. This shift in perspective, of conceptualizing dosage as *discrete* events rather than energy averaged over a mass, will be vehemently resisted by the regulatory bodies fronting for the Cult of Nuclearists. To acknowledge that the fluence of charged particles through a cell is the critical phenomenon for determining biological effect would necessitate admitting that internal emitters represent an enhanced hazard over external radiation and that the chemical form of the internal emitter must be taken into account when evaluating risk. The European Committee on Radiation Risk acknowledges the importance of these variables for biological effect and has added weighting factors to traditional dose calculations to take them into account. Why is this important? Take depleted uranium as an example. As we have seen, when the energy emitted by uranium is averaged over a large volume of tissue, the dose of energy it delivers appears insignificant, and DU weapons are made to appear harmless. However, when account is taken of the fact that uranium is an internal emitter of alpha particles, that each alpha emission violently disturbs only a small volume of cells in its immediate vicinity (increasing the probability of genetic damage to those cells actually hit or to bystander cells) and that certain compounds of uranium have an affinity for binding to DNA, the purported harmlessness of DU is unmasked as barefaced treachery.

Recent research confirms the enhanced hazard posed by the alpha emissions of depleted uranium. Scientists at the Radiation and Genome Stability Unit at Harwell in Oxfordshire, UK, working in conjunction with Mount Vernon Hospital in London, produced direct evidence that a single alpha particle emitted from DU can produce unrepaired genetic alterations in cells that are passed on to daughter cells during cell division. Groups of human blood cells were exposed to a single alpha particle and left to divide a dozen times or more. Study of this cell population revealed that 25% of the daughter cells had distinctive patterns of bent and broken chromosomes. Such damage can be a precursor to cancer expression. According to Professor Dudley Goodhead, the Harwell unit's director: "This work shows for the first time that even a single alpha particle can induce genomic instability in a cell" (Edwards 2001).

SCAM NUMBER TWELVE: Mislead the public into believing that science has definitively established that low doses of radiation present no risk to health.

In the article "Radiation Protection — Science in Crisis: Flaws in NRPB Modeling" on the website of the Low Level Radiation Campaign, the following quotation from UNSCEAR 2000 is reproduced:

> Risk estimates for the induction of human disease are obtained primarily from epidemiological studies. These studies can clearly distinguish radiation effects only at relatively high doses and dose rates. To gain information at low doses and dose rates, which are more relevant to typical human radiation exposures, it is necessary to extrapolate the results of these studies. To be valid, this extrapolation requires a detailed understanding of the mechanisms by which radiation induces cancer and genetic disorders [emphasis added].

The punch line of the article is sobering: "Nobody knows the mechanisms by which radiation induces cancer and genetic disorders. What more do we need to say?"

Their point, although simply stated, carries profound implications. As long as science remains ignorant of the mechanisms by which radiation is carcinogenic, the conclusion that low doses of radiation pose no hazard to health is crackbrained and indefensible. *In vitro* studies clearly demonstrate that the lowest conceivable dose of radiation, a single particle track through a cell, can produce irreparable genetic damage. Until the intermediary steps between this event and the onset of cancer are fully understood, it is reckless to discount the carcinogenic potential of low doses of radiation. Consequently, the assertion that uranium weapons pose no radiological hazard to health is groundless and without merit.

The dumping of DU on the homeland of our enemies is just part of a much larger campaign to economically dispose of radioactive waste by dispersing it haphazardly over the surface of the Earth. Rationalizing their deeds by their flawed theory of radiation effects, representatives of the US government are currently crafting policies of reckless lunacy. If these regulators and lawmakers have their way, disposal of significant portions of the low-level radioactive waste stream will be deregulated, allowing this material to be legally dumped into unlicensed sites such as local municipal garbage dumps, landfills and hazardous waste sites. Such disposal will create long-lived contamination of soils and groundwater, creating yet another channel for the internal contamination of unwitting citizens. To vastly compound the threat, provisions are being enacted to allow recyclers to acquire castoff radioactive material and convert it into construction materials and consumer goods. Deregulation will pave the way for 1,250,000,000 pounds of depleted uranium to be dumped into the marketplace. To compound the nightmare, radioactive scrap metal salvaged from nuclear weapons fuel-chain facilities and decommissioned power plants will be freely available for mixing and smelting with regular scrap metal and then distributed to industry. This practice is already permitted in Europe. Consumers will be oblivious to the fact that the ornaments of daily life will be the repository of radioactive waste. Cars, pots and pans, buckles, wristbands, jewelry, bicycles, playground equipment, and

potentially everything else made from recycled metal, will ferry radiation into human proximity.

In addition to metals, other materials that have acquired radioactivity are planned for release into the general environment. These include concrete, plastics, asphalt and soils. Once incorporated into the general recycling stream, this material will become invisible and ubiquitous. Consumers will be clueless as to which items they purchase contain radionuclides. Will this create a hazardous situation? The experts will spout the tired lies that the increased dose to the population will be minuscule, yet again trying to befuddle everyone into thinking that external radiation is the only avenue of harm. But bring to mind the workers and the do-it-yourselfers who will be unaware that some of the materials they use are contaminated. All operations which include milling, cutting, sanding, sawing, and burning will release radioactive particles into the air, making them available for internal contamination via ingestion and inhalation. Consider the following scenarios: a road worker sawing into concrete contaminated with radionuclides, a construction worker breathing in the dust of a demolished building built with contaminated materials, a fireman breathing in the smoke of a burning vehicle made from recycled scrap metal. Internal contamination by a wide variety of radioisotopes is being readied for large sections of unsuspecting humanity. The inevitable radiation-induced illnesses will again cause an invisible plague of untraceable origins.

The initiative to contaminate the Earth with increased levels of background radiation is broad-based and international. In the United States, its is supported by the Department of Energy, the Nuclear Regulatory Commission, the Department of Transportation, the Environmental Protection Agency, the Tennessee Department of Environment and Conservation, and the California Department of Health Services. Internationally, it is supported by the United Nations International Atomic Energy Agency (IAEA), the European Commission, Euratom (the European atomic energy agency), and the governments of nations that possess nuclear weapons and reactors. The same people responsible for initiating the globalization of trade, finance and government have included the universal contamination of the biosphere in their agenda. The IAEA, through its affiliation with the United Nations and its transport organizations, the International Maritime Organization and the International Civil Aeronautics Organization, is actively advocating to get all member countries of the UN to adopt the transport recommendations it developed with both industry and Euratom. Adoption of these measures will permit free, unregulated international commerce in contaminated materials and consumer goods.

A relatively recent event testifies to the type of mayhem these policies will lead to and the negative health consequences that will assuredly follow. In late May 1998, a steel

mill in Spain unknowingly vented a plume of cesium-137 into the atmosphere. The wind-blown contamination set off alarms in France, Switzerland, Italy, Austria, Germany, Bulgaria, the Czech Republic and Greece. The radioactivity was released during the smelting of scrapped metal equipment. According to Spain's Nuclear Security Council, the metal had been screened for radioactivity, but the specialized equipment had been lined with an absorbent material that prevented detection.

Depleted uranium munitions are a harbinger of a new world order, one characterized by ongoing radioactive contamination of the Earth. They are a forerunner, and they forewarn, of future devil-may-care practices of dispersing radioactive waste amidst populations and detonating nuclear/radiological weapons. The clarion call has sounded, and we have been warned.

SCAM NUMBER THIRTEEN: Promote simplistic, all-encompassing hypotheses of the relationship between dosage and physiological response to spellbind the public into believing that more is known about the effect of low doses of radiation than is actually the case.

Resolution of the debate over the hazards of low doses of radiation is hampered by the difficulty of designing and carrying out conclusive, indisputable, epidemiological studies. Dr. Alice Stewart succinctly diagnosed the problems confronting such research:

> Studies of the health effects of very small doses of radiation face three design problems: how to accurately measure the radiation doses large numbers of persons have received (the dosimetry problem), how to prevent comparisons between exposed and unexposed groups from being bedeviled by other differences (the selection problem), and how to cope with the varying lengths of cancer latency (the follow-up problem). These technical problems lie at the center of the current debate about the cancer effects of low levels of radiation, and the cancer issue is central to the controversy about nuclear technology.

The absence of firm data on population effects from low-dose exposure has forced various interest groups to field their own mutually exclusive hypotheses of what the actual hazard *might* be. All such attempts to date have been overly reductionistic. All rely on an oversimplification of the complex processes that biological systems undergo in response to radiation exposure. All fail to account for all the available data. The dose-response models proposed have been derived by extrapolation from known high-dose effects down into a region of heightened uncertainty. Confirmation of the accuracy of such modeling has been frustrated by a paucity of incontrovertible evidence. As noted by the ECRR: "In the

case of external irradiation studies, the small populations studied result in wide confidence intervals and a number of different curves can be drawn through the data." This arcane subject of postulating the shape of the curve on a graph is the battlefield where pro- and anti-nuclear gladiators collide. "The disagreement concerns how to extrapolate from higher dose rates to the non-measurable range. The rancorous discord among scientists concerning the low-dose cancer danger is over hypotheses — not observable fact" (Ball).

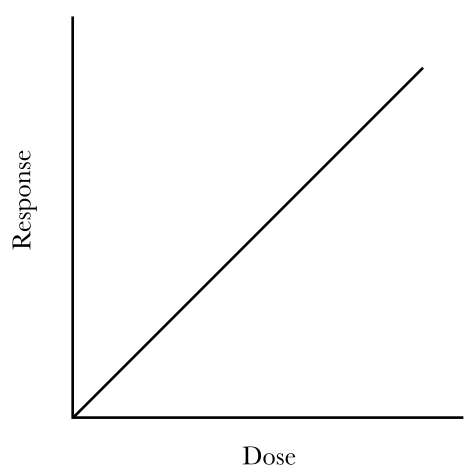
The central question in the field of radiation safety is this: What is the relationship between a dose of radiation and the biological effect produced by that dose? At relatively high doses, answers to this question are straightforward. Some biological effects are non-stochastic, i.e., deterministic. A threshold dose must occur for these effects to be produced and the severity of the effects are directly proportional to the size of the dose. Examples of nonstochastic effects are acute radiation syndrome, cataract formation and skin burns. As the dose of radiation decreases, *apparent* deterministic effects disappear. In addition to these types of effects, radiation produces stochastic effects. These effects are produced by chance. Within current orthodox thinking, the stochastic effects of concern are cancer and genetic defects. At relatively high doses, as the dose increases the *probability* of stochastic effects likewise increases. Similarly, a decrease in dosage is accompanied by a reduced *probability* of a stochastic effect occurring.

Because of such problems as those mentioned by Alice Stewart for conducting epidemiological studies that will produce unequivocal results, various models have been proposed to capture the *true* relationship, as dosages decrease, between the dose received and the probability of a stochastic effect occurring. Since at relatively high dosages, the likelihood of stochastic effects is directly proportional to the dose, one model proposes that this proportional relationship exists down to the lowest possible dose. Another model postulates that at low doses more health detriment per unit dose is produced than that predicted by the linear relationship. A third prominent model proposes the opposite, that less health detriment per unit dose occurs. The Holy Grail in radiation research is to determine which model successfully captures the reality of what is actually going on.

Radiation protection agencies throughout the world have embraced the premise that biological damage from radiation exposure is directly proportional to the dose. This is called the Linear No-Threshold Hypothesis (LNTH). According to this model, the probability of an individual developing cancer is linearly related to the amount of radiation he/she receives. Applied to populations, the LNTH posits that as the radiation dose to members of the population increases, the number of cancers induced in that populations increases at the same rate. This hypothesis is supported by a great deal of empirical data based on relatively high levels of exposure to external irradiation. The problem is that suf-

ficient data is not available to determine definitively that this relationship continues to hold as doses become smaller and smaller. For regulatory purposes, radiation protection agencies have adopted the LNTH "as if" it were true. They believe that this stance is overly conservative in estimating the hazard of low doses and offers the greatest measure of safety to radiation workers and the general public. Embedded in this model is the idea that the incidence of cancer is the same whether the radiation is delivered as a high dose in a short period of time or as a low dose over an extended period of time. Small doses are cumulative and each exposure increases the risk to the individual. According to the LNTH, there is no such thing as a threshold dose below which there are no adverse effects to health. Regardless of how small the dose, some probability always exists that a cancer will be induced.

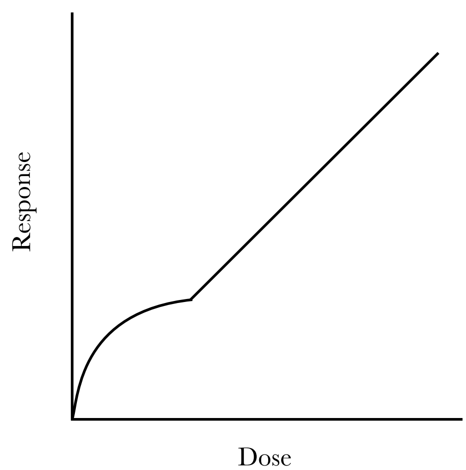
The Linear No-Threshold Hypothesis



The Supralinear Hypothesis represents a direct attack to the status quo of the nuclear establishment. According to a small number of dissenters, the LNTH dangerously underestimates the hazards to health of low doses of radiation. In their view, the existing data provides ample evidence that in the low dose range, 10 rem (0.1 Sievert) or less, more damage is created per unit dose than that predicted by a simple linear relationship. This counterintuitive conclusion is supported by a number of observations cited by the ECRR. For instance, the genetic instability and bystander effects induced in cell cultures by very low doses demonstrate a supralinear response. *In vitro* studies also provide evidence

that free radicals, produced from the ionization of water molecules, have a tumor-promoting effect that enhances the hazard of low-dose radiation and alters the shape of the dose-response curve to one of supralinearity. Increased health detriment at low doses has also been attributed to the Petkau effect, described later in this chapter, whereby sparse free radical production can promote cell death through cell-membrane destruction. This phenomenon has been postulated as having a debilitating effect on the immune system, causing an elevated rate of cancer in the low-dose range. The hypothesis that the risk of cancer death per rad increases as the dose decreases was demonstrated by Gofman in his reanalysis of the Hiroshima Life Span Study. He showed that this data exhibited a supralinear relationship for breast cancer, leukemia, and overall deaths. The ECRR has concluded that sufficient evidence exists to reject the LNTH as inaccurate in the low dose range and favors relationships which show much greater effects per unit dose.

The Supralinear Hypothesis



A third competing model for low-dose effects is the Linear Quadratic Hypothesis. According to this viewpoint, hazard at low doses is even less than that postulated by the LNTH, the risk of cancer death per rad decreases as the dose decreases. This conclusion is supported by data that shows that the body has numerous mechanisms for mitigating the effects of radiation damage. These mechanisms kick in at different dosages, and thus, simple extrapolation from high doses down to low doses cannot be made accurately.

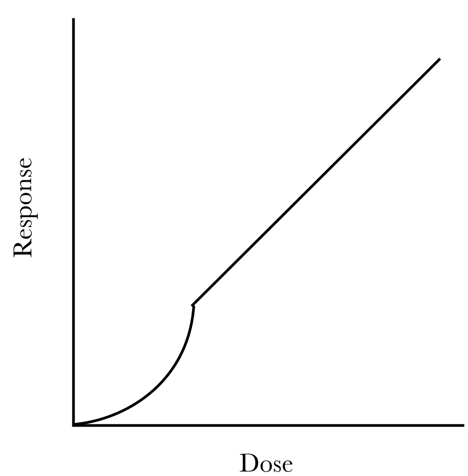
The ECRR have postulated an explanation for effects manifesting a linear quadrat-

ic dose response:

> There are sound theoretical reasons for interpreting this [a Linear Quadratic response] as due to independent track action in the linear range with a much increased effect when the dose is so great that two tracks impinge on a cell at the same time. These two tracks (or correlated tracks) are thought by most to have a high probability of inducing a mutation because they can cause damage to both DNA strands in such a way that there is a 'double-strand break,' an event which is difficult for the cell to repair. This may not be the true reason for the increased mutation efficiency but the observation that two hits have a very much larger chance of causing mutation is now well accepted. Recent work with alpha particles and cell cultures has confirmed this empirically (ECRR).

What this means is that at the lowest possible dosages, not all cells within a population are hit, and those that are hit are extremely unlikely to be sufficiently damaged by a single hit to cause irreparable mutation or to be hit twice to produce a double-strand break.

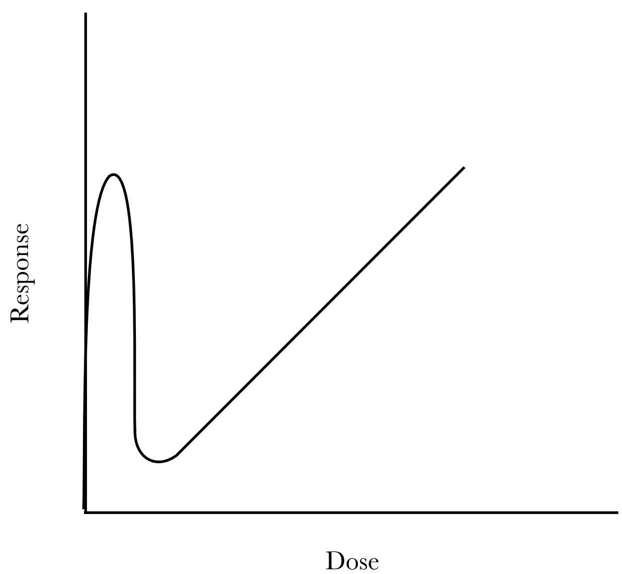
The Linear Quadratic Hypothesis



As the dose increases, the percentage of cells in the population that are hit increases as well as those receiving two or more hits. Finally, when a sufficient percentage of the cells receives two or more hits, the likelihood of irreparable mutation becomes directly related to the dosage. The dose-response curve then becomes linear.

The ECRR has drawn attention to research which displays a fourth dose-response curve. This curve displays a biphasic relationship. In some cell culture experiments, as the dose increases from zero, the effect increases to a maximum point. With further increase in dose, the effect falls back to a minimum. As the dose increases still further, a second rise in effect is witnessed. Busby has proposed an interesting explanation for this phenomenon. Within the body, different types of cells have different sensitivity to radiation. Further, at any one moment in time, a percentage of cells throughout the organism is undergoing replication. During this time, they are in a heightened state of sensitivity to radiation damage. As the dose increases from zero, the first cells to sustain damage are among those that are the most sensitive. They will be exposed to a greater likelihood of irreparable mutation and cancer induction. As the dose increases still further, these most sensitive cells will be killed rather than survive in a mutated form. This cell death cancels out the potential deleterious effects to the organism from the oncogenic events at lower doses. Thus, potential detriment to the organism decreases. At still greater doses, the less sensitive cells will begin to respond and the effect will once again increase and continue to do so with increasing doses until expression of a cancer or death to the organism from radiation illness.

Biphasic Dose-Response Curve



The quest for a universal hypothesis to encompass and explain all responses of the

organism to all doses harkens back to the time when physicists dominated the discussion on the health effects of radiation. What was sought was a tidy, all-inclusive model of how radiation affects the human organism, from the tiniest of exposures up through to a lethal dose. However, no evidence has ever been presented that biology is amenable to such oversimplification. As far as we know, it is nothing more than wishful thinking to hope that a single, universal dose-response relationship can be found to account for all types of exposure to all types of cells in all individuals and for all possible effects. It is conceivable that each of the dose-response models that have been proposed hold true under various circumstances or for different medical endpoints under consideration.

The health of humanity is being jeopardized by the reductionistic thinking embodied in the dose-response models embraced by the radiation protection agencies. Often, epidemiological evidence is rejected as being invalid because it fails to conform to what the models predict *should* be observable. A case in point is the cancer clusters found in proximity to nuclear installations. Another is the debilitated health of those exposed to uranium weaponry. Rather than calling the models into question, such evidence is rejected by those in authority as being invalid and unscientific because it is at odds with the accepted models. Once again this is a distortion of the scientific method. As noted by the ECRR:

> There is not sufficient evidence to show that there is a universal dose-response relation for all types of exposure and all endpoints, and to assume such a function is an example of a fatal reductionism. However, there are good reasons for assuming that effects in the low dose range from zero dose to about 10 mSv are likely to follow some kind of supralinear or fractional exponent function. Since there is good theoretical and empirical evidence for the existence of biphasic dose response relationships, the committee strongly recommends that no epidemiological findings should be dismissed on the basis that it does not conform to a continuously increasing dose response relation of any form.

The reader is cautioned not to get sucked into the vortex of confusion created by the academic debate over how to extrapolate known high-dose effects to low levels of exposure. The Cult of Nuclearists profits from the irresolution of this controversy and has a vested interest in keeping it alive. While academicians argue over the shape of the dose-response curve, the United States military is saturating other peoples' homelands with just those levels of radiation that are being argued over. As long as consensus among the experts remains unachieved, the United States can disguise itself in pristine innocence and escape accountability for its crimes.

SCAM NUMBER FOURTEEN: Deviously initiate a propaganda campaign to overturn conventional wisdom on dose-response relationships in order to achieve a political objective.

Uranium weapons are being used by the US military in each new overseas conflict. The government is proposing the development of a new generation of nuclear weapons and a possible resumption of testing at the Nevada Test Site. Worldwide, articles are appearing with increasing regularity describing the next incarnation of nuclear power reactors that are destined to solve all our energy needs. Proposed deregulation of the disposal of low-level radioactive waste (see Scam Twelve) is paving the way for a flood of radioactive material to enter the marketplace. Against this backdrop, a pregnant, rhetorical question needs to be posed: Isn't it a remarkable coincidence that, just now when these advances in the proliferation of nuclear technologies are underway and waste disposal policies are changing, a concerted attempt is afoot to demolish the Linear No-Threshold Hypothesis currently embraced by the radiation protection agencies and replace it with a dose-response model that will justify increased low-dose exposure to the public?

For the Cult of Nuclearists, the Supralinear Hypothesis has always been an enemy. It predicts greater health detriment to the population from low doses of radiation than admitted by the radiation protection agencies. But the Linear No-Threshold Hypothesis is falling into increasing disfavor as well. Regulatory constraints based on this model are an interference to practices that release increased levels of radiation into the environment and elevate human exposure. Looser waste disposal policies or new weapon development may be stymied if regulatory agencies don't loosen up a little bit with regard to the amount of exposure allowed to the public. Cleanup of nuclear waste sites will eat up gargantuan amounts of money if current guidelines continue to be enforced. In addition to these inconveniences, the LNTH is undermining the nuclear establishment because it reinforces the public's fear of radiation. Embodied within its premises is the idea that no dose of radiation is safe, that even the lowest doses are creating a health detriment to a small portion of the population. This leads in an unfortunate direction. Uranium weapons *are* inducing cancer in some number of those exposed. With the LNTH causing such problems, the Cult of Nuclearists has hatched a brilliant new public relations strategy within the last decade to convince the world that exposure to low levels of radiation is without risk. The public needs to be versed in this latest tactic so as to spot representatives of the Cult of Nuclearists and understand the reason for the current push not only to refute all evidence of detrimental low-level effects but to completely dismantle a century of study in radiotoxicology and radiation protection. What follows is a summary of the various arguments that are appearing with increasing frequency in the media and the scientific journals, implanted there to reassure the public that exposure to low doses of radiation should no longer be a concern.

(The flaws in these arguments will be addressed in later scams.)

1. In this clever public relations campaign, the Cult of Nuclearists borrows tactics from its critics and attacks the ICRP. The argument is made that the ICRP has perpetrated a fraud against humanity by basing radiation protection standards on the Linear No-Threshold Hypothesis. The validity of this hypothesis for postulating the detrimental health effects of low doses of radiation, so the argument goes, has never been confirmed by experimentation. The only reason the radiation protection agencies adopted this hypothesis was that it was assumed to be overly conservative. The nuclear industry raised no objection because it could easily operate within the safety standards developed on the basis of the LNTH.

2. The LNTH is now entrenched and will be difficult to change. Beginning in the mid-1960s, the anti-nuclear movement gained tremendous momentum. Under its tutelage, the scientific hypothesis that small amounts of radiation **MAY** be hazardous was corrupted into the political agenda that a small amount of radiation **IS** hazardous. Spurred by anti-nuclear activists, the public has developed an unreasonable fear of any amount of radiation exposure. If the LNTH is scrapped for a more scientifically sound basis of radiation protection, anti-nuclear organizations will accuse regulatory agencies of jeopardizing public health. The public's radiophobia unduly hampers the nuclear industry from providing to society the enormous benefits promised by radioactive materials.

3. Research has revealed that the human body has numerous mechanisms for repairing radiation damage or inducing cell death in damaged cells before they have the opportunity to undergo replication. Consequently, some as yet unidentified threshold dose or threshold mechanism must exist before the onset of cancer expression.

4. The DNA in each cell is subject to tens of thousands of damaging events each day from oxidative metabolism and other normal physiological processes. This damage is successfully corrected by normal repair mechanisms. Compared to this normal level of damage, the amount of DNA damage induced by low-level radiation is insignificant. Whatever damage is produced in DNA by low-level radiation will be lost amid the other assaults to DNA and will likely be effectively repaired. Further, since numerous carcinogens are attempting to assault the integrity of DNA in modern humans, there is no way to isolate radiation-induced damage and award it special significance as being more hazardous.

5. The modern understanding of the etiology of cancer testifies against the simple model of carcinogenesis embraced by the radiation protection agencies. Cancer induction is not a straightforward process following inexorably from radiation-induced DNA damage

within single cells. The initiation of malignancy is a complex, multistage process requiring several key changes in different parts of the genome. Low doses of radiation cannot produce all the necessary alterations simultaneously. Thus, cells suffering genetic mutation from low-dose radiation must undergo further genetic alterations from other events and/or other sources before evolving into a malignant genotype. Further, carcinogenesis is intercellular. Innumerable iterative steps which are unpredictable in their effect to the overall process take place between the malignant transformation of a single cell and the proliferation of a cancer consisting of billions of cells. Such complexity precludes postulating a simple linear relationship between dose and response.

6. The phenomenon of hormesis testifies to the fact that exposure to low levels of radiation are beneficial to the human body. Hormesis refers to the stimulating and apparently protective effect conferred on living systems by exposure to low doses of radiation and low doses of other toxic substances. A wealth of experimental evidence exists that demonstrate that low levels of radiation can act as a stimulant to a variety of cellular functions, enhancing repair mechanisms and immunological responses.

7. Natural background radiation varies at different points on the Earth by a factor of 10 or more. Populations living in areas of high levels of natural background radiation show no evidence of increased adverse health effects when compared to populations living in areas of lower levels of natural background radiation. Quite obviously, humans possess adaptive mechanisms allowing them to handle increased amounts of radiation with no ill effects. Thus, the addition of a little more human-generated radiation above background levels cannot reasonably be deemed harmful.

8. Low levels of radiation stimulate adaptive mechanisms at both the cellular level and the level of the whole organism. A cell exposed to a high challenging dose evidences less radiation damage if it was previously exposed to a low conditioning dose. The initial dose stimulates adaptive mechanisms that enable the cell to manage greater radiation insult at a later date. Some evidence has been gathered demonstrating that the same phenomenon is manifested in people who live in areas of high natural background radiation. Having adapted to higher-than-average levels of radiation, they give signs of increased resistance to radiation exposure above familiar background levels.

9. The radiation protection agencies throughout the world need to be faulted for ignoring the beneficial effects of low doses of radiation (hormesis) or the zero (nonexistent) effects. By such a one-sided outlook, their recommendations are unbalanced and biased. They emphasize the bad potentialities of radiation exposure and ignore the good. This bias

is out of sync with today's scientific climate, and it serves to prejudice the people against the nuclear industry.

10. Enormous sums of money are being unnecessarily spent annually to assure dosages to the public are below those wrongfully hypothesized as harmful by the Linear No-Threshold Hypothesis. Cleanup and decommissioning of nuclear sites worldwide are projected to cost close to $2 trillion. Due to the low levels of radiation involved in many instances, this expenditure will produce negligible public health and safety benefits. The money can be better spent elsewhere.

These 10 points summarize the new paradigm on low-level radiation effects being promulgated by the Cult of Nuclearists. The implications of this paradigm shift, in regard to uranium weaponry, are troubling. Taken to its logical extreme, the people of Afghanistan and Iraq should offer thanks to United States for bombing them with uranium and exposing them to the health-enhancing benefits of low doses of radiation. In its beneficence, US weaponry is stimulating a variety of physiological functions, improving cellular repair mechanisms, and enhancing immunological responses.

The Cult of Nuclearists ardently desires to convince all listeners that it has assembled sufficient proof to warrant a significant overhaul of radiation protection standards as they apply to low-dose exposure. Their argument rests on three major premises which they promote as being thoroughly validated by experimentation. This is a gross misrepresentation, for their conjectures are still open to a wide range of interpretations and have yet to be shown to provide a realistic basis for protecting the population from radiation injury. The first premise: the phenomenon of hormesis testifies to the fact that cellular systems can remain unharmed by low doses of radiation and actually benefit from such exposure. Repair mechanisms within cells are stimulated and immune function is enhanced, conferring a protective benefit to the organism as a whole. The second premise: due to the remarkable efficiency of DNA repair mechanisms within cells, the immune system has the capacity of perfectly repairing every type of damage capable of being produced by low-dose radiation. The third premise: below some threshold dose, radiation causes no ill effect to the organism. The new paradigm reintroduces the concept of a threshold dose for the onset of radiation-induced malignancy. Based on the concepts of hormesis and perfect repair of radiation damage, the evident conclusion is that a yet unidentified dose is required to initiate a series of events that eventually trips some threshold mechanism before radiation-induced damage can escape repair and develop into uncontrolled cell proliferation.

A large body of evidence has accumulated to substantiate the existence of hormesis. But pro-nuclear lobbyists are making unwarranted extrapolations from the phenomenon,

claiming that it proves that all low-dose exposure is harmless. Is it not possible that, while some health benefits are conferred, *simultaneously* some subpopulation of the cells or organisms exposed suffer unrepaired or misrepaired genetic lesions which are precursors to cancer? In agreement with this line of reasoning, Dr. Rosalie Bertell offers the following observation on the subject of hormesis:

> What has been sorely neglected in this public relations battle is that low dose radiation at the cellular level must necessarily affect a large range of molecules in the cellular communication system in any particular cell type. In order to produce one "good" effect, one must endure many other unwanted "bad" effects which will in the long run claim a physiological price perhaps significant, although they evolve to a clinically observable level more slowly (Calabrese; Bertell 1998).

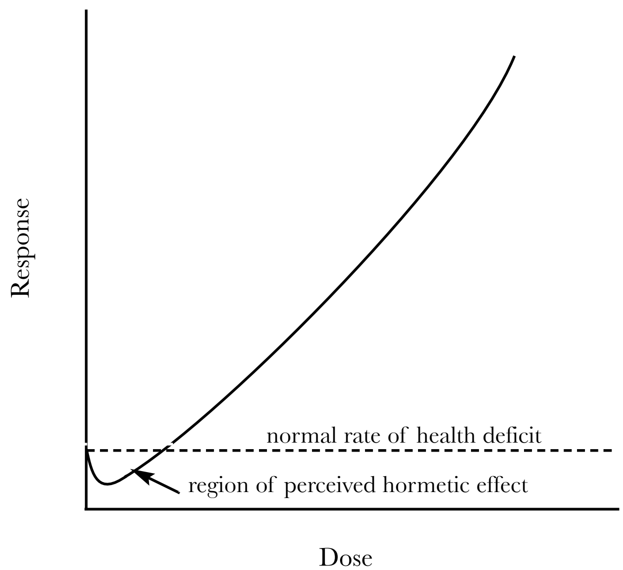
The phenomenon of hormesis, as interesting as it is, is really irrelevant to the topic of radiation protection and is sorely abused by those who reference it when attempting to dismiss the hazards of low-dose exposure. This is made clear by Makhijani, Smith and Thorne in *Science for the Vulnerable: Setting Radiation and Multiple Exposure Environmental Health Standards to Protect Those Most at Risk*:

> There are some who subscribe to the "hormesis" hypothesis, according to which a small amount of radiation could produce some beneficial health effects, by stimulating the immune system for instance. The main evidence put forward for this has been from experiments on mice. According to a summary of the evidence for the hormesis effect, compiled by Charles Waldren, a high dose of radiation produced fewer mutations in some circumstances if preceded by a dose in the 1 to 20 rem range. This supposed protective effect does not appear at lower or higher doses, however, and lasts only for about a day, after which it disappears (Waldren 1999). Such a hormesis effect, even if it exists in humans, has no public health significance, since the cancer risk of the exposure would be very high and any immune system stimulation would be very temporary. This issue has been extensively addressed by the BEIR VII panel and others. The conclusion of the BEIR VII panel was that "the assumption that any stimulatory hormetic effects from low doses of ionizing radiation will have a significant health benefit to humans that exceeds potential detrimental effects from the radiation exposure is unwarranted at this time" (NRC 2006).

The ECRR offers an interesting observation on the phenomenon of hormesis that

requires further investigation. If one plots the hormesis dose-response curve, one gets the following graph:

Hormesis Dose-Response Curve

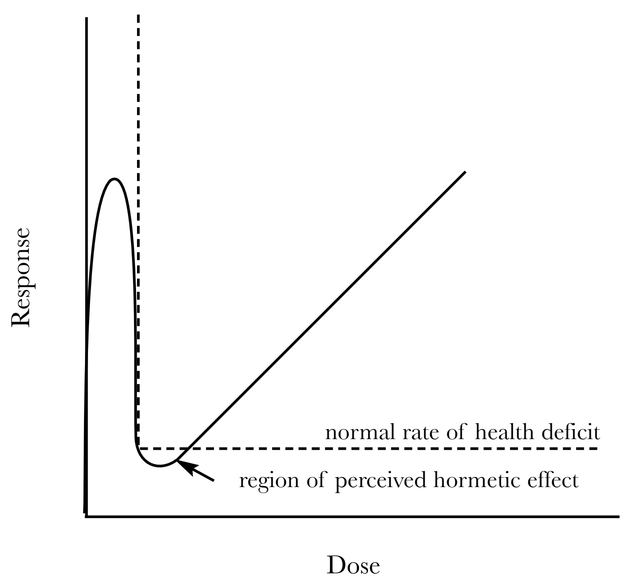


Reading this graph from left to right, one sees a dipping of effect, initially, as dose increases, before the line turns upward and begins to exhibit the more familiar curve of increasing effect with increasing doses. The region of the dip is the region where the beneficial effects of hormesis are observed. Less cancer is observed within that interval, and the assumed conclusion is that radiation is conferring a beneficial effect. Somehow the organism is deriving benefit from the dose. Interestingly, the curve resembles part of the graph reproduced earlier illustrating the biphasic dose-response model. As stated by the ECRR:

> It may be, however, that some of the hormesis evidence results from an artifact. If the dose response in the low range follows a biphasic curve, all that is needed to show an apparent hormetic effect is to leave out the zero dose/zero effect point. It may be that because deductive conclusions from high-dose experiments could not be squared with

the possibility of such variation in this low dose region, either the points were interpreted as scatter or they were forced into a hormesis dip by leaving out the lowest dose responses as outliers.

Postulated Origin of the Hormetic Dose-Response Curve



To translate: The apparent benefit of radiation in the low-dose region emerges as a result of failing to detect or account for evidence of the initial spike in the dose response curve. In this region the most sensitive cells initially undergo increased rates of mutation and cancer induction. With increasing dosage, these cells are killed off and health detriment lessens, and the graph descends vertically. The region of hormesis is misinterpreted as a region where the organism derives benefit. But this dip represents nothing more than a transition from one phase of damage to the system to the next. The same reasoning may explain certain epidemiological studies attempting to prove the beneficial nature of high background radiation because of a lower incidence of cancer. Perhaps a better explanation is that the background radiation has been responsible for selecting for radiation resistance in a population by culling out radiosensitive individuals. The apparent health benefit is nothing more than what remains when low-level radiation has eliminated the most sensitive.

In an attempt to acquit low-level radiation of doing harm, supporters of hormesis frequently cite studies which they claim show lower rates of cancer mortality in geographic areas with higher-than-average levels of natural background radiation. However, their interpretation of these studies is open to question. In the article "Altitude, Radiation, and Mortality from Cancer and Heart Disease," a number of such studies were analyzed. Under this scrutiny, the reality for hormesis became questionable. According to the authors of this review: "When we adjust linearly for altitude, the negative correlations between mortality and background radiation all disappear or become positive. We see no support here for the claim that ionizing radiation is beneficial at low doses" (Weinberg, Brown and Hoel). After an exhaustive analysis of confirmed low-dose health effects in "Inconsistencies and Open Questions Regarding Low-Dose Health Effects of Ionizing Radiation," authors Nussbaum and Kohnlein make the following observation:

> All of the low-dose studies of radiation effects in human populations reviewed above are inconsistent with hypothesized long-term cancer-reducing effects of such exposures in excess of unavoidable natural background of human populations (hormesis). One can only speculate about the continued popularity of this conjecture among some groups of radiation experts.

The call to permit higher levels of radiation exposure only makes sense if there is unmistakable proof that a threshold dose must exist for the onset of irreversible radiation injury. This means that the damage produced by doses below this threshold are flawlessly repaired. One hidden assumption in this conjecture is that all people in the population have equivalent immune systems and that there is not a range in immune response between people. If such a range is admitted, then radiation protection standards must address the most vulnerable among the population or the value judgment must be made explicit that these people should be put at heightened risk of radiation induced illness so that the rest of the population can benefit. But there is a deeper problem with the conjecture of perfect repair. Evidence exists that the immune system makes mistakes when repairing DNA lesions. In chapter 18 of his book *Radiation-Induced Cancer from Low-Dose Exposure*, Gofman presents a powerful argument for why irreversible genetic damage, and thus cancer induction, can occur at even the lowest levels of exposure. His argument is based on the fact that the cellular mechanisms for repairing carcinogenic injuries do not operate flawlessly. Thus, "repair" is at the heart of the threshold issue:

> The radiation-induced cancers arising from the unrepaired lesions at low doses do not wear a little flag identifying them as any different from cancers induced by higher doses of radiation, or induced by causes entirely unrelated to radiation. Therefore, threshold propo-

> nents cannot argue that the cancers arising from the lowest conceivable doses of radiation will somehow be eliminated by the immune system or any other bodily defenses against cancer. Such an argument would require the elimination of cancer in general by such defenses. Instead, we observe that cancer is a major killer (roughly 15-20% of many populations). So the proposition would lead to a non-credible consequence, and must be rejected. This means that repair is the key.

Gofman's analysis proceeds by first reviewing nine reputable low-dose studies: the Nova Scotia Fluoroscopy Study, the Israeli Scalp-Irradiation Study, the Massachusetts Fluoroscopy study, the Canadian Fluoroscopy Study, the Stewart In-Utero Series, the MacMahon In-Utero Series, the British Luminizer Study, the Harvey Twins In-Utero Series, and the Israeli Breast-Cancer in Scalp-Irradiation Study. These studies involved a range of exposures from 9.0 rads down to 0.1 rad which Gofman translates into 12 tracks per nucleus per exposure down to 0.29 tracks per nucleus. His argument is that if flawless repair exists at some threshold dose, every carcinogenic lesion will be successfully undone below that dose and no excess cancers will be induced. However, in every study an excess of cancers was in evidence. Gofman summarizes the conclusion of this line of reasoning as follows:

> 1. One primary ionization track is the least possible disturbance which can occur at the cellular level from ionizing radiation. Without a track, there is no dose at all.
>
> 2. Every primary ionization track has a chance of inducing cancer by inducing carcinogenic injuries; it needs no help from any other track.
>
> 3. This means that there is no conceivable dose or dose-rate which can be safe, unless (A) the repair system always successfully undoes every carcinogenic lesion, when the dose or dose-rate is sufficiently low, or (B) every failure of the repair system, at low doses, is always successfully eliminated by some post-repair defense system.
>
> 4. Human epidemiological evidence shows that the repair system for radiation-induced carcinogenic lesions has a failure rate even under minimal strain.
>
> 5. Observation and logic show that the post-repair defense systems (for instance, the immune system) cannot possibly be perfect with respect to providing a safe dose or dose-rate of ionizing radiation.

> It follows that there is no safe dose or dose-rate of ionizing radiation, with respect to induction of human cancer. The risk is related to dose, right down to zero dose.

SCAM NUMBER FIFTEEN : Rely on your models to create reality.

When radiation is liberated into the environment, either from an accident at a nuclear power plant or the incineration of a uranium weapon, where does the radiation go? Given sufficient motivation, time and money, radiation monitors can be dispatched into the field and laboriously map in what direction the radiation traveled, where it was deposited, and the number of people potentially exposed. Depending on the radioisotopes involved and the level of contamination drifting through the air or settling to contaminate potable water sources and agricultural products, *very fuzzy estimates* can be *manufactured* of what the *possible* external and internal dosages to the members of the exposed population *might* be. Assembling the picture of what has occurred is arduous and the outcome is, at best, an educated guess. Until an easy and rapid method is devised and implemented for measuring external exposure history and internal contamination among large numbers of people, actual dosages of an at-risk population are not ascertainable. Because we cannot/do not measure where all those radioactive atoms go and who accumulates them and in what concentrations, and because radiation biology is still in its infancy in determining the full range of biological effects produced in those contaminated, there is tremendous uncertainty as to the outcome of a radiation release on public health. The powers that be will adamantly deny this assessment.

As an alternative to actually going out to measure and map the full consequences of an environmental release of radiation, methods have been developed to "model" what *might actually* be taking place. For such a model to have any validity, a number must first be derived representing the dose of radiation received by each member of the exposed population. Once again, "averaging" is the relied upon methodology. An average dose is postulated for an average individual within the exposed group. Among the factors taken into account in deriving this number are the radioisotopes involved, the type of radiation these emit, the energy transmitted by the radiation, the external hazard from gamma emitters, the organ(s) of retention of internal emitters, and the residency time of the internal emitters within the various organs of the body. The total energy the average person is thought to have received is stated in a unit of measure called the "person-rem" or "person-Sievert." This number is then multiplied by the number of people in the exposed population to derive the "collective dose." By multiplying this number by the appropriate risk factor(s) [to be explained later], a quick estimate can be derived of how many cancers and of what type are likely to develop in the exposed population over their lifetime as a result of the collec-

tive exposure. This methodology has great utilitarian value because it can very rapidly provide a rough guess of the possible health consequences from routine or accidental emissions.

Needless to say, the concept of collective dose, similar to that of the concept of dose, is vulnerable to a range of abuses from mild massaging to gross misrepresentation. Scams, identical to the ones previously mentioned, can be applied to the concept of collective dose to paint the desired image of the consequences of a radiation release. The assumptions made by researchers in their determination of such variables as the amount of radiation released, the average dose, or number of people exposed can sculpt the derived collective dose into any number of different guises.

The idea of collective dose is grounded in the very abstract and dubious notion that such a thing as an average dose can be derived that faithfully represents the exposure received by each member of a population. Implicit in the concept is the assumption that radiation is uniformly distributed, that no hotspots develop that enhance exposure to local groups, that dietary habits are similar throughout the population and all members ingest similar diets that contain equivalent quantities of radiocontaminants. Perhaps more importantly, the concept of collective dose assumes uniform vulnerability to radiation injury, failing to take into account the heightened vulnerability of such subgroups as women, children, fetuses, those who are genetically predisposed to above average radiosensitivity and people with compromised immune systems. This is analogous to the hot particle problem where some cells in an organ receive no hits and a few receive huge numbers of hits, for many in a population may receive no exposure while some small fraction may receive a highly significant dose. Averaging the radiation over the whole population may have the effect of understating the health impact.

To predict the number of cancers likely to be induced in the exposed population, the collective dose is multiplied by the appropriate risk factor(s) published by the radiation protection agencies. These risk factors are derived from the rates of cancer observed in epidemiological studies that have achieved consensual acceptance by the radiation protection community, such as the corrupted Hiroshima study, and from the model of dose-response favored by whoever is doing the predicting. Radiation protection agencies currently rely on the Linear No-Threshold Hypothesis to develop risk factors and to predict the incidence of cancer in the aftermath of a radiation release.

The reason for the vehement clash over the shape of the dose-response curve in the low-dose range can now be readily understood. The model creates reality. The model chosen

to represent the human organism's response to radiation controls the prediction of the public health impact of a radiation release. The number of people *known* to develop cancer as the result of a radiation accident is largely determined by the model chosen to evaluate the event. Radiogenic cancers can take as long as decades to develop after exposure. These cancers become masked by normal incidence rates of the disease. Normal fluctuations from year to year in cancer deaths and the number of cases of new cancers can disguise the contribution played by a radiation event in sickening the population. Epidemiological studies have the potential of providing answers, but they are challenging to design and implement so as to deliver unambiguous results. To fill the knowledge void, researchers and public health officials turn to the currently accepted models to explain the health implications of an incident. Knowledge of the radioisotopes released, their quantities, and the number of people exposed are all that is necessary to do the math to determine the number of cancers likely to be produced. The answer may have little to do with what is actually but invisibly taking place in the population. But that doesn't matter. Here and now, all that matters is what people believe is happening. The truth, if it is rigorously pursued, won't be known for decades. The models relied upon to interpret events forge the perception.

To date, the collective dose from radiation incidents has been filtered through the Linear No-Threshold Hypothesis to derive the cancer consequences of the events. The Cult of Nuclearists can no longer allow this conservative and precautionary approach to craft the public's perception when it concerns mass exposure of populations to low doses of radiation. The LNTH produces the unwelcome prediction that cancers inevitably will be produced. This conclusion is repellent and an obstacle to the public acquiescing to the proliferation of uranium weapons, nuclear bunker-busters, small fourth-generation fusion weapons, and a resumption in nuclear testing at the Nevada Test Site. What can be done to alter public opinion? The answer is obvious. Change your model. And that is exactly what is being done through the current push to discredit the LNTH and replace it with a model that postulates that low-dose exposure is without hazard.

SCAM NUMBER SIXTEEN: Conduct spurious diagnostic tests on possible victims of internal contamination and then use the inevitable negative test results to falsely reassure the patients that their dose was nonexistent or inconsequential.

Despicable and unconscionable are adjectives too tame to adequately convey the gravity of this scam. Nevertheless, it is currently being used against ailing American veterans returning from combat duty. Due to the controversy over depleted uranium, many vets suffering from Gulf War Syndrome want to know whether DU contamination is a factor in their symptomatology. The standard diagnostic test administered by the military is to collect a 24-hour urine sample and measure the total concentration of uranium within the

sample so as to ascertain whether uranium levels are elevated above normal. This sounds perfectly reasonable. A veteran, not adequately informed, will greet the inevitable negative tests results with relief, assured that internal contamination with uranium is not a factor in his illness. A casualty of misplaced trust, he will remain ignorant that he has been a victim of a medical hoax intentionally perpetrated by the Pentagon to hide from the world the consequences of uranium weaponry. **Measurement of total uranium in urine is the wrong diagnostic test**. When a human being assimilates soluble uranium compounds into his body, almost all of that uranium remains mobilized within the body and is rapidly eliminated through the urine in a matter of days. Thus, the total concentration of uranium in the urine will quickly return to normal levels. The tiny percentage of uranium lodged in tissues of retention, such as bone, will slowly leach into the circulation and then into the urine. This uranium will mix with the naturally present uranium in the body and is unlikely to elevate total uranium concentrations beyond the normal range. Consequently, it is evident that unless a urine sample is collected within days of exposure, this test will provide no information as to whether or not the soldier has been internally contaminated. This, however, is not the whole story. It is quite possible that a GI on active duty will inhale a medically significant quantity of *insoluble* uranium compounds. These may become immobilized in the lungs or trapped within the tracheobronchial lymph nodes, irradiating surrounding tissue for years or decades. Slow to leach into the general circulation, this contamination may go undetected because it does not significantly elevate uranium levels in the urine above normal. Quite obviously, a different diagnostic test is required to prove contamination with battlefield uranium. The fact that the ratio of uranium isotopes is different in depleted uranium from that in the uranium naturally found in the body, the only legitimate test is one that measures the composition of the various isotopes of uranium being excreted in the urine. (A fuller description of this procedure appeared in the chapter, *A Primer in the Art of Deception*.)

This author, in full cognizance of the responsibility of his words, stands before all mankind and unhesitatingly declares that the Veterans Administration is perpetrating medical fraud on ailing military personnel. Further, the Department of Defense of the United States is endorsing this medical malpractice to deceive the entire world on the health implications of battlefield DU. Military physicians, if they keep abreast of the scientific advances in their field pertinent to their profession, know with certainty that they are prescribing the wrong diagnostic test. They cannot use ignorance as an excuse.

SCAM NUMBER SEVENTEEN: Disembowel the profession of health physics to such an extent that its members will turn a blind eye to the misdeeds of Government.

Of what use is the profession of health physics in protecting humanity from the haz-

ards of radiation if none of its practitioners has the courage to speak out against Government abuse of science as exemplified by any of the previously mentioned scams?

Up to this point in Exhibit E, we have scrutinized that pesky and dodgy character *dose*, and witnessed some of the antics it is called upon to perform in the highly politicized extravaganza of downplaying the hazards of exposure to ionizing radiation. The time has come to turn attention to the other prankster in the carnival: *risk*. Determining the risks to health that accompany exposure is a central objective of the science of radiation protection. No sane community of human beings is going to allow the dispersal of a toxin within its midst unless it is confident that it has correctly assessed that toxin's risk to health and found that risk to be acceptable. Analyzing ionizing radiation's impact on health is a labyrinthine exercise, and conventionally, the issue has been the province of experts in the field. Due to the complexity of the subject matter, laymen have been forced to surrender their well-being to the radiation protection community and government decision makers. In a world operating on the principle that truth is the fundamental priority, this delegation of authority to the experts and those in power would be adequate to guarantee public health and communal well-being. Unfortunately, those who control the assessment of risk simultaneously control the perception of risk, and too much evidence has accumulated bearing witness to the fact that the integrity of the radiation protection community has been compromised by proponents of nuclear/radiological weaponry and commercial nuclear power. When the experts and those who sponsor them have their own priorities that take precedence over truth, the public is vulnerable to abuse. The fabric of a free and democratic society is rent asunder when its guardian institutions traffic in mischief in matters of basic science and replace truth with falsehood for the benefit of vested interests.

To estimate the potential threat to an individual or a population following a radiation release, the first requirement is a determination of the probable dosages involved. The scams revealed up to this point amply illustrate that the seemingly straightforward process of establishing objective dose measurements is an opportunity for great rascality and devilment. In addition to dosages, a body of epidemiological studies must be available that demonstrate from previous instances of exposure the relationship that exists between the size of a radiation dose and the incidence of disease. Exhibit C reviewed some of the currently relied upon studies and demonstrated their limitations. In particular, it highlighted the prominent place awarded the corrupted Hiroshima study and detailed how this study has been purposely designed to skew risk assessment in favor of the nuclear industry for generations to come. A third essential element for evaluating the risks following a radiation event is a reliable model of dose-response into which new data can be plugged in to derive estimates of collective health detriment in an emergency. For scenarios of low-dose exposure, the favored method of extrapolation from high-dose effects is the fundamental deter-

minant of what risks are thought to exist. This explains the fierceness of the battle over the shape of the dose-response curve. The reigning model controls the perception of risk. From this point, a disturbing conclusion emerges: the objectivity of science is a myth. Those in power control the science, and they use their corrupted science to justify whatever programs they elect to sponsor.

When the human organism is exposed to ionizing radiation, deterministic effects and/or stochastic effects may be induced. A deterministic (nonstochastic) effect occurs when exposure exceeds some threshold dose and results directly from the effects of the killing of cells. It's a predictable outcome observed in most or all of those receiving the threshold level of exposure, and its severity is dose-related. Deterministic effects have yet to be identified as occurring at low dosages. In contrast, stochastic effects are those that depend upon chance or probability. In whole-body doses of less than one sievert (100 rems), stochastic effects are the predominant concern. In doses above one sievert, stochastic effects can be produced in addition to deterministic effects. Cancer and inheritable genetic damage are examples of stochastic effects. These effects arise from cells that are altered by radiation and that manage to survive. The *probability* of their occurrence increases as the dose increases, but their severity is independent of dosage. At present, the majority of radiation scientists operate on the assumption that there is no minimum threshold dose required to induce stochastic effects. Even a single track through a cell, the lowest possible dose, is thought capable of producing stochastic effects, though the probability of this occurring is extremely low. This point is a major source of contention due to the many uncertainties of effect in the low-dose range. When stochastic effects are produced, they are initiated at the moment of exposure, but years or decades might elapse before the whole-organism response to these changes manifest as altered functioning and ill health.

In harmony with the computational system for determining dosages, mathematical models have been developed to assess the risk of cancer in both individuals and whole populations following radiation exposure. A number of organizations involved in radiation protection, such as UNSCEAR, BEIR, ICRP, and the Environmental Protection Agency (EPA), have published estimates of risk. Although differing in minor ways, they all are in substantial agreement. These estimates are based on the study of survivors from the bombings of Hiroshima and Nagasaki, on groups who received radiation for diagnostic or therapeutic purposes, and workers who received occupational exposure. Successful modeling of the risk of cancer incidence demands consideration on a wide range of variables. According to BEIR V:

> The risk depends on the particular kind of cancer; on the age and sex of the person exposed; on the magnitude of the dose to a particular

> organ; on the quality of the radiation; on the nature of the exposure, whether brief or chronic; on the presence of factors such as exposure to other carcinogens and promoters that may interact with the radiation; and on individual characteristics that cannot be specified but which may help to explain why some persons do and others do not develop cancers when similarly exposed.

For the sake of simplicity, the mathematical model to assess risk can be reduced to its bare essentials. Only three numbers are required to estimate the increased risk of cancer to a population resulting from radiation exposure: the dose to the average individual, the number of people receiving that dose, and the risk factor applicable to the type of cancer under consideration. To give an example, if the average dose to a population of 10 people is 100 rems, the collective dose is 1,000 person-rems (10 x 100). Similarly, if the average dose received by a population of 10,000 people is 0.1 rem, the collective dose works out to be the same: 1,000 person-rems. In order to calculate the number of fatal cancers expected in the two populations, the collective dose is multiplied by the appropriate risk factor. The risk factors per sievert (per 100 rems) have been developed by the international radiation protection agencies to cover different scenarios of whole-body exposure and/or exposure to individual tissues and organs. Note that when the identical collective dose in the two examples mentioned above are multiplied by the same risk factor, the number of cancers anticipated in each population is the same. This conclusion is a consequence of the Linear No-Threshold Hypothesis. Cancer yield is proportional to the collective dose. The same numbers of cancers will be produced whether 1,000,000 people each receive a thousandth of a rem or 1,000 people each receive one rem. In the low-dose range, this assumption of linearity is under increasing fire for either under- or overestimating the cancer yield or for being woefully simplistic.

To appreciate the function played by risk factors in estimating cancer incidence, a simple example will suffice. The 1990 ICRP absolute risk value for fatal cancer probability in the high dose and high dose region was 8 x 10^{-2} (0.08) per sievert. To calculate the number of fatal cancers in an exposed population, this risk factor is multiplied by the average dose to each member of the population which in turn is multiplied by the number of people receiving that dose. Thus, if 10,000 people each receive a dose of 1 sievert, the probable number of fatal cancers will be 800. (0.08 x 1.0 x 10,000 = 800). The utilitarian value of this methodology is obvious. In the aftermath of a radiation release, an estimate can be quickly generated satisfying the intellectual desire to come to terms with the health consequences of what has taken place long before the actual pain and suffering becomes apparent within the population, if they ever become apparent at all. (Of course, the stricken victim will be aware of his own pain and suffering, but he may be handicapped by the long latency period of radiation-induced cancer of ever knowing if the origin of his

illness is radiation-related.)

Because it is difficult to observe low-dose effects in populations, attempts at estimation have extrapolated from relatively reliable high-dose effects. The data from Japan clearly shows an adverse health effect among adults who received a dose above 200 milliSieverts (20 rems) and children who received a dose about 100 milliSieverts (10 rems). The key question that draws daggers out from underneath lab coats is, what is the risk to health at levels of exposure below these dosages?

To gain an appreciation of the difficulties of determining cancer incidence at low doses, let's suppose that in a population of 10,000 people, each member received a dose of only 10 millisieverts (1 rem, i.e., one hundredth of the previous example.) The expected number of fatal cancers in this instance would be 8 (0.08 x 0.01 x 10,000 = 8). Normally, approximately 20% of the population dies of cancer. So rather than 2,000 cancer deaths, the expected number of cancer deaths in the exposed population would be 2,008. Due to statistical fluctuations and normal levels of uncertainty, there is no way to be sure that radiation caused excess cancers in this population. As Caufield observes:

> With such a large base of cancers, it may be statistically impossible to detect a relatively small number of extra cancer deaths. Some scientists argue that in order to get statistically reliable data on the effects of doses on the order of one rem, it would be necessary to study 10 million exposed people, and a matching group of ten million people who have not been exposed to radiation. Matters are further complicated by the need to continue a study from the first exposure until death.

Given these uncertainties, the radiation protection agencies rely on their risk factors for interpreting the health consequences of radiation accidents and planned radiation releases. These risk factors are the eyes for all human beings who wish to evaluate radiation effects, for they enable us to see what is invisible and unmeasurable. They inform us of the level of human suffering produced by nuclear weapons, nuclear reactors, radioactive waste, and now, non-nuclear weapons containing radioactive material.

At this juncture, the reader might reflect on a number of questions: What if the risk factors are wrong? What if they produce calculations that misrepresent, by underestimating, the actual health consequences of human exposure to radiation? Given that in the absence of direct observation, the risk factors are the central window through which we perceive the hazards of a radiation release, are they not the likely focal point for intentional malfeasance by the Cult of Nuclearists so as to keep the world ignorant of the breadth

of their misdeeds? And finally, isn't the *raison d'être* of the corrupted Hiroshima study now perfectly clear, since by it, the current risk factors are justified?

If the risk factors are wrong, humanity has been hoodwinked and rendered blind by artful lies. Crimes against humanity and crimes against life can be committed before our very eyes, and we will fail to see them for what they are. Could there be a more perfect crime than one committed before a world of blindfolded witnesses?

Exhibit F will testify to the falsehood of the current risk factors. But before we walk down that road, we must first explore the vagaries of that shifty character called "risk," and observe some of the many tricks its handlers can make it perform to alter the perception of hazard of ionizing radiation.

SCAM NUMBER EIGHTEEN: Base estimates of health risks from chronic exposure to internal emitters upon instances of acute flashes of external exposure.

This scam is the centerpiece for much of the current mischief perpetrated by the radiation protection agencies. It is the practical implementation of the falsehoods rehearsed in Exhibits A, B and C. It is grounded upon the dubious premise, which has gained ascendancy in the discipline of health physics, that *all* types of health detriment from *all* types of radiation exposure is simply related to the total amount of energy absorbed. No distinction is made between energy delivered to the body externally by photons and energy delivered internally by alpha and beta particles, despite the fact that these can create completely different spatial and temporal patterns of molecular damage to cells and organs. In the case of external irradiation, the total amount of energy deposited in the body is conceptualized as being uniformly distributed, or "averaged," over the target mass, be it the whole body or a particular organ. How risky this dose is for inducing cancer can then be estimated by consulting a handful of studies of acute external irradiation, the most prominent being the corrupted Hiroshima Life Span Study. The identical method, without question as to its legitimacy, is used for instances of internal contamination. First, the total energy emitted by embedded hot particles is calculated. This quantity is treated *as if* it were uniformly distributed throughout the target organ, even though in many circumstances this is certainly not the case. The likelihood of illness is then predicted according to the studies of external radiation. What is important to note is that the risk factors, the probability of cancer incidence, for the different types of exposure are derived from the same source: the corrupted Hiroshima study and the handful of other studies of external exposure. By this method, the radiation protection agencies pitch to the world their central, unverified hypothesis: that the biological response of chronic low-dose exposure to

internal emitters incorporated in the body from nuclear pollution in the environment in no way differs from that produced by an instantaneous flash of gamma irradiation at one moment in time. By the logic of this schema, the data from the highly politicized Life Span Study insinuates itself into forecasts about the health consequences of chronic, internal, low-dose exposure from such situations as Chernobyl, living downwind from a nuclear installation, and inhaling weaponized uranium. Exhibit F will bear witness that this methodology produces risk factors that repeatedly underestimate the number of radiation-induced illnesses inflicted on the innocent and unsuspecting throughout the world.

SCAM NUMBER NINETEEN: Mislead the world into believing that, below the dosages where deterministic effects begin to occur, the only health concern from radiation exposure is the risk of cancer.

To ensure the continuation of programs that contaminate the biosphere with radiation, the Cult of Nuclearists must downplay the detriment to public health that accompanies their deeds. A major tactic in this campaign is to fixate the attention of the public on the idea that the fundamental risk to health following radiation exposure is cancer. In living systems, the molecular damage produced by radiation injures the structure and function of cells. Vulnerable to harm are both the germ cells (the cells responsible for reproduction) and somatic cells (all the other types of cells making up the organism). For the individual receiving radiation exposure, the source of any health detriment is produced from damage to somatic cells. Damage to germ cells carries the additional risk of impacting on the health of offspring, from the moment of conception to birth and then onward through to old age until the final death of that individual. The central focus of radiobiology for the last half century has been the quest to understand how radiation can damage DNA and lead to cancer. Little research has been devoted to understanding non-cancerous processes induced by DNA damage, and the implications these have on cell function and the health of the organism as a whole. The entire biochemical structure and function of a cell or its descendants is vulnerable to radiation-induced alteration, depending on where along a chromosome damage is incurred. The science of radiation effects remains in its infancy.

Given that cancer is a recognized outcome of radiation exposure, the public health focus of the radiation protection agencies has been to assess the risk to the population from all types of exposure for all types of cancer. The probability of cancer is predicted by the risk factors embraced by the radiation protection agencies. In the high-dose range, these are based on the accepted epidemiological studies. In the low and intermediate dose ranges, extrapolations are made from known high-dose effects. For radiation protection purposes, a linear relationship is assumed between dose and cancer yield. According to the ECRR, for the ICRP, UNSCEAR, BEIR, NCRP, NRPB, and the state agencies of the

member nations of the European Union, the only health effects considered to be produced by low-level radiation are **"fatal"** cancers, heritable damage, and IQ retardation. Members of the public may find this disquieting. **What about nonfatal cancers and benign tumors?** The incidence of these are many times more frequent than fatal cancers, and if nothing else, they adversely affect quality of life and take a toll on psychological/emotional well-being. Damage to germ cells with resulting hereditary disorders is acknowledged by the radiation protection agencies as a possible outcome of low-level radiation exposure, but the claim is made that these have yet to be identified as occurring in man. (Evidence to prove that this position is incorrect will be presented in Exhibit F.) According to the ECRR, "the ICRP only considers heritable effects which are measurable in phenotype after birth, e.g., congenital defects and perhaps increases in clinically diagnosed heritable genetic diseases." However, there are other possible consequences of germ cell injury which are recognized by the ECRR but ignored by the radiation protection agencies that establish risk factors for radiation injury. Germ cell injury may produce developmental problems to the fetus from the moment of fertilization onward. These may result in spontaneous abortions or fetal deaths. Is the public informed that this is a possible outcome of low-level radiation exposure? No! Further, as a result of radiation-induced germ cell injury, a newborn child may carry in its mutated DNA non-apparent abnormalities that may cause or contribute to the full gamut of possible illnesses later in life. Is the public informed that this is a possible outcome of low-level radiation exposure? No! Aside from inherited damage, there are risks other than cancer to the developing fetus from low-level radiation exposure in the womb. These, also, are not adequately addressed by the radiation protection agencies. Given the vulnerability of the developing fetus for "low probability" events producing "high impact" effects, no consideration is given to the effect of low-level radiation on the birth rate within populations, the incidence of low birthweight babies, and the rate of infant mortality. Is the public informed that these are a possible outcome of low-level radiation exposure? No!

Epidemiological studies have produced evidence of a wide range of health effects other than cancer. These are not addressed by the radiation "protection" community. To avoid repetition, the reader is directed to a fuller discussion of this topic in the last section of the chapter *A Primer in the Art of Deception*.

SCAM NUMBER TWENTY: Entrust agencies of questionable objectivity with the power to establish the risk factors for low-level radiation exposure.

Historically, the radiation protection agencies and the committees that publish estimates of radiation risk have been staffed by people with close ties to government nuclear programs and the nuclear industry. When establishing guidelines for radiation safety, a fun-

damental consideration was the development of a system that enabled those with interests in nuclear technology to go about their business without undue interference. This clandestine alliance between regulators and users has introduced bias into the science of radiation protection and has ultimately been responsible for many of the scams unveiled in this Exhibit.

In the circle game of radiation protection, the ICRP earns its status and legitimacy from the regulatory bodies of governments that consult it for advice. Completing the circle, the radiation safety standards of a nation are deemed legitimate because they issue from such an authoritative and respected body as the ICRP. This incestuous relationship had its start at the beginning of the nuclear age, in 1946, when the AEC sought guidelines from the newly reformed NCRP, which it helped to establish through Lauriston Taylor. This, in turn, led to the formation of the ICRP. Today, the ICRP takes the position that its function is nothing more than to offer recommendations on radiation safety. In a meeting in Brussels in 1998, as recounted in the first publication of the ECRR, the scientific secretary of the ICRP, Dr. Valentin, told attendees that "the ICRP was an independent body which gave advice on radiation safety, but that those who considered this advice unsafe or questionable were entirely free to consult any other group or organization" (ECRR). As fair and open-minded as this may sound, the ruse in the matter is that governments consult only the ICRP and the other copycat agencies when authoring laws and regulatory policies for their nuclear programs. Any individual or group is free to author whatever dissenting opinion they wish on the current safety of radiation standards, but it won't make a damn bit of difference to the entrenched power structure and the nuclear programs it sponsors.

One would think that with the variety of international organizations involved in radiation safety, a number of different points of view on the hazards of low-level exposure would be represented. However, this is not the case. Except for minor differences, the various agencies base their work on the same assumptions and come up with similar risk assessments. They all embrace the flawed methodology outlined in Exhibits A, B, and D, and they all base their assessment of the risk of chronic, low-level internal radiation exposure primarily on the corrupted Hiroshima study or on other studies of acute, external exposure. All discount as inconsequential the health detriment posed by low doses of radiation. This unanimity of opinion can be interpreted in two different ways: either the science is so well understood that there is little room for disagreement, or a political agenda has taken hold of the various radiation protection agencies in order to control the perception of hazard posed by radiation exposure.

Control over what ideas occupy the minds of human beings are the stakes being

played for in the debate over radiation risk. Those organizations fronting for the nuclear establishment promote a single, unified, dogmatic point of view of what risks are imposed on humanity. Given the influence and power of this tyrannical system, a new organization such as the ECRR should be welcomed into the debate for it provides fresh ideas, allowing the public to weigh alternatives and engage in free thought. To gain an appreciation of the importance for alternative points of view, it is instructive to compare the predictions of ICRP models and those of the ECRR on the losses imposed on humanity by nuclear technology. For instance, ICRP models predict that the worldwide health detriment from all nuclear activities[12] up to the year 2000 is 1,173,606 extra cancer deaths and 2,350,000 total cancers. Under these models, no infant deaths or fetal deaths are predicted as having occurred. By contrast, the ECRR has calculated an alternative picture of reality by adding additional risk factors to the ICRP methodology to fill perceived inaccuracies in that system. The ECRR models estimate the worldwide health detriment as totaling 61,619,512 extra cancer deaths and a total of 123,239,024 induced cancers. Further, they estimate that the human nuclear experiment has produced 1,600,000 infant deaths and 1,880,000 fetal deaths. Similarly, the predicted mortality from the accident at Chernobyl differs widely. ICRP models predict an excess of 30,000 fatal cancers worldwide, a figure that will be statistically invisible within normal population incidences of the disease. By contrast, ECRR models predict that the overall 70 year yield of fatal cancers, in Belarus alone, will be 1,200,000. Global figures are predicted to be in excess of 6,000,000.

The reason for these wide discrepancies rests primarily on how the ICRP and ECRR models estimate the health detriment produced by internal emitters. This is the crux of the debate on low-level radiation effects. As we have seen throughout this chapter, the ICRP predicts health effects by calculating the total amount of energy absorbed by the body or organ from decaying radioisotopes external to the body and deposited internally, weights the contributions of alpha emitters within the body's interior, and then averages the total energy over the mass under consideration (whole body or organ) to derive a dose. In sharp contrast, the ECRR model partitions internal and external doses. The calculation of the internal dose, contrary to ICRP methodology, includes weighting factors that take into consideration the specific biophysical and biochemical behavior of each isotope within the body and, further, discriminates between whether the isotope(s) is distributed as individual molecules or as sub-micron or micron-sized hot particles.

The skirmish over dose-response is not simply some esoteric and theoretical controversy by the experts with no practical significance for the rest of humanity. The fate of the

[12] This includes global nuclear tests, weapons fabrication, nuclear power production, radioisotope production, and accidents.

whole human race may very well rest upon it. Our ideas of the anticipated effects of a nuclear exchange, the amount of wellness sacrificed to our continued reliance on nuclear power, the health detriment imposed on a population by uranium weapons, all rest on the model we choose for faithfully portraying reality.

SCAM NUMBER TWENTY-ONE: Alter population statistics to completely corrupt accurate risk assessments.

For those readers who have yet withheld judgment as to the malevolence of the Cult of Nuclearists and their ruthless determination to impose their deadly technology upon the world, the time has come to shine a light through the veils of their treachery and explore the true depths of their malfeasance. Epidemiology is an esteemed and precious tool in the hands of humanity for assessing trends in public health and identifying environmental hazards that are producing illness and ruining people's lives. The foundation of a successful epidemiological study is accurate information of normal trends of morbidity and mortality within a population. If this baseline is tampered with, the opportunity for discovering truth disappears. The inquiring mind is set adrift in misconceptions with no prospect of ever coming ashore to reality. The intentional manipulation of data to misdirect knowledge is nothing less than brainwashing and mind control. It is victimization of the human intellect, the implanting of an insurmountable obstacle in the minds of people who thirst for an accurate picture of what is transpiring in the world around them. The Cult of Nuclearists stands guilty of inflicting this havoc into the minds, into the lives, of an unsuspecting humanity.

Evidence for this crime is meticulously laid out by Jay Gould and Benjamin Goldman in their book *Deadly Deceit: Low Level Radiation, High Level Cover-Up*. The authors recount how, using mortality data collected from official death certificates, they set about to discover if evidence existed for excess deaths occurring in the wake of radiation releases from reactors at weapon production facilities and commercial nuclear power plants. In addition to confirming increased mortality to populations exposed to low-level radiation vented into the environment, the authors made the startling and disturbing discovery of "outright falsification of published data." Analyzing discrepancies in mortality data published by the government, the authors uncovered proof that official statistics on mortality and morbidity had been intentionally tampered with in an attempt to cover up deaths in the US population caused by radiation vented into the environment.

In the course of their research, Gould and Goldman mined data from three series of publications authored by the Public Health Service, a subsidiary of the Department of

Health, Education, and Welfare. One publication was *Radiation Data and Reports*, a monthly publication compiling radiation readings in the environment as reported by a network of recording stations throughout the United States. A second publication was *Monthly Vital Statistics Report*, a state-by-state tabulation of infant mortality and total deaths. The data recorded within these pages each month was referred to as mortality "by place of occurrence." It contained information on where deaths actually occurred, not necessarily where the deceased dwelt during their lifetime. In the following year, after new, revised data had been obtained, revisions to the monthly mortality information were published. This allowed for a comparison between the data as originally recorded and the data as it appeared after revision. The third publication consulted by the authors was *Vital Statistics of the United States*. This single volume contained a yearlong compilation of the data recorded in the monthly reports. It contained adjustments to the incidents of mortality by place of occurrence to provide an accurate picture of mortality "by place of residence." Each volume of this publication appeared in print a couple of years after the year of monthly reports it summarized. Among researchers from a wide variety of disciplines, *Vital Statistics of the United States* was considered the standard reference for US mortality data. It was easier to work with than the monthly copies reporting on a single year, and it was more widely available in public libraries.

Cross-referencing these three publications, Gould and Goldman made a number of disturbing discoveries.

1. One issue explored by the authors was the health consequences of a radiation accident that had received scant public attention. On October 1, 1988, news belatedly reached the public domain of two radiation accidents in November and December 1970 at the Savannah River nuclear weapons facility in South Carolina. In each of these months, nuclear fuel rods suffered a meltdown. There was an information blackout as to what quantities of radiation, if any, were released over the downwind population. The news that eventually reached the public was this: "E.I. du Pont de Nemours and Company, which operated the Savannah River Plant at the time of the accidents, ran a full-page advertisement in *The New York Times* that claimed 'the radioactivity given off was kept within the building' and 'no one, on or off site, was ever harmed.'" Exploring the veracity of this claim, Gould and Goldman compared published radiation measurements with published mortality data. What they uncovered put E.I. du Pont de Nemours and Company to shame. As reported by the researchers:

> Results of an examination of government databases were startling: after the two accidents in November and December 1970, radioactivity had increased significantly in the milk and rain of South Carolina

> and throughout the Southeast. Peaks in infant and total mortality showed up immediately following the accidents and disturbing longer-term mortality trends appeared also in the region.
>
> Radioactivity in South Carolina's rain, as measured for December 1970, jumped six-fold over the same month in the previous year. This jump in beta radiation occurred immediately after the accidents in November-December 1970. The rise was significantly above the local trend in the preceding 22 months and it was three times greater than the US rise. Also, in the Southeast as a whole, radioactivity in the rain doubled over the previous December (1.2 times greater than the US rise.) The average reading for the Southeast was higher than any other region in the country: five times higher than the Northeast and West and 70 times higher than the Midwest.
>
> Milk was also contaminated. Radiation readings indicate that the level of strontium-90 found in South Carolina's pasteurized milk during the summer following the Savannah River Plant accident rose significantly over the previous summer. Whereas, the level declined in the milk in the rest of the country.
>
> Immediately after the elevated radioactivity was found in the rain, South Carolina's infant mortality rate in January 1971 peaked at 24 percent above the previous January. In contrast, it declined in the US and Southeast during the same period.
>
> Total deaths in South Carolina also diverged significantly from the rest of the country during the months immediately following the accidents, declining six percent slower than the US since the previous January.

Elevated peaks in both infant mortality and total deaths were recorded in *Monthly Vital Statistics Report* for January 1971. Revised figures corrected for errors from late filings, faulty death certificates, computer malfunctions and random mistakes appeared in the same publication a year later. These were in substantial agreement with the original data. But in the final bound volumes of *Vital Statistics of the United States* published in 1974, ***the peaks in infant and total mortality disappeared. The data had been altered completely.*** "In the final by-residence data, South Carolina's January change over the previous year became the same or less than the US change, whereas it had been significantly higher for both infant and total mortality in the revised by-occurrence data." In this instance, increased mortality was covered up through a substantial lowering of the numbers

of deaths that had previously been reported in the monthly statistics. Suspiciously, such wide discrepancies between mortality "by place of occurrence" and mortality "by place of residence" occurred **only** after significant radiation releases:

> Presumably, these deaths were now missing because all of these babies had travelled from out-of-state that month to die. The subtraction of 38 dead babies in South Carolina the month after the Savannah River Plant accidents can be compared to 59 missing infant deaths in Maryland during July 1980, right after a Three Mile Island venting, and eighty-six missing in Pennsylvania during July 1979, right after the Three Mile Island accident. In all three cases, peaks in infant mortality were eliminated as a result of the revisions.

2. Another type of suspicious tampering of population statistics appeared after the accident at Three Mile Island. In every month of 1979 after the accident, mortality data for California, Minnesota, and Illinois were missing from successive issues of *Monthly Vital Statistics Report*. "These highly irregular omissions made it impossible to evaluate the significance of mortality increases in areas near Three Mile Island, **because the baseline US mortality trend could not be calculated**" (emphasis added).

3. In 1986, after fallout from the Chernobyl catastrophe reached the United States, dramatic revisions appeared in the monthly mortality data. "Some states markedly increased their reported number of live births in *Monthly Vital Statistics Report*. Since the number of births is the denominator in an infant mortality rate, increasing this number lowers the rate." Small random fluctuations in the birth data are expected due to late filings as is the case for the filing of late death certificates. These changes then appear in the revised data published the following year. However, as the authors relate, preposterous tampering with the birth rate was in evidence.

> Revisions to the 1986 birth data for California and Massachusetts, however, were all positive and clearly nonrandom, adding nearly 45,000 live births to their original totals. Exactly 813 births were added for each of five successive months to Massachusetts' monthly data. The next three months, the changes were 703, 702, and 703. The nine upward revisions in California's birth data were all combinations of 5000, 4000, and 4415. At the same time, there were no major revisions in the reported number of infant deaths. The result was that Massachusett's June 1986 infant mortality rate was lowered by 76 percent and California's July infant mortality by over 25 percent. In this way, the large infant mortality peaks in the original data

for California and Massachusetts after Chernobyl were eliminated.

4. In January 1987, in the year following Chernobyl, the format of *Monthly Vital Statistics Report* was changed. Revisions made to data from the previous year were no longer marked. By this means, identification and analysis of changes were made significantly more difficult. Details of changes were replaced by a generic note at the bottom of each page which stated "figures for earlier years may differ from those previously published." As Gould and Goldman observe: "Now, the individual changes are not only unexplained, they are also no longer identified."

5. The authors identified a number of instances where crucial information from *Radiation Data and Reports* was omitted. Starting in 1967, the recording station 140 miles downwind of the Savannah River Plant ceased to publish any information on radiation levels in the environment. In 1975, the Environmental Protection Agency assumed the responsibility from HEW for collecting and publishing data about radiation in the environment. Monthly publication of *Radiation Data and Reports* was halted. A quarterly report with a much smaller circulation replaced it. Detailed information was no longer made available about radiation levels in the environs around government weapons facilities, radioactivity in the food supply, and strontium-90 in bone.

6. Starting in 1975, the Environmental Protection Agency centralized environmental monitoring by collecting milk samples, rain samples, and air filters from all over the country and shipping them for analysis to the laboratory of the Eastern Environmental Radiation Facility in Montgomery, Alabama. One of the practices introduced at this institution was the reporting of "negative" radiation values for milk. This is a curious adoption given the fact that a negative amount of radiation is about as real as a Heffalump. Gould and Goldman offer the following explanation for this procedure:

If the radiation in milk is lower than background levels that are due to cosmic rays, radon, and other natural sources, then small "negative" readings occur. Under this system, there are normally as many small positive as negative values for short-lived substances such as iodine-131 and barium-140 that decay in a matter of a few weeks. As statistically expected, the numbers are rarely larger than four or five units and average out to zero over a period of a few months to a year.

Not surprisingly, these negative values began to play a nefarious role in covering up radiation released into the environment. Contrary to the expectations expressed by Gould and Goldman for the frequency and magnitude of negative values, occasional reports were issued that contained many more negative values than positive values, and the negative values

were of unusually large magnitudes. One example is in the aftermath of an underground nuclear detonation at the Nevada Test Site in the summer of 1982 which was suspected of releasing radiation into the environment. As reported by Gould and Goldman:

> Large positive readings of barium-140 and iodine-131 in the milk would have been an unequivocal signature of leaks from the underground tests. Instead, barium-140 in Nevada milk reached the incredible value of negative 42 picocuries per liter in June 1982, the most significant negative reading in the nation. Out of a total of 62 barium-140 measurements reported for the US that month, an astounding 57 were negative! Eight western states neighboring Nevada also had negative barium-140 measurements that diminished in magnitude with distance away from the test site. In sharp contrast, no such clear-cut pattern existed for the month of March, when the magnitude of negative radioactivity in the milk was ten times less in Nevada than in June, and there only were small positive and negative fluctuations as expected under normal conditions.

The authors report other abuses of negative radiation readings. In June of 1982, there was a cluster of negative readings of iodine-131 in New England. That was the same month in which two serious radiation accidents occurred at the Pilgrim nuclear power plant in Massachusetts. As in Nevada, the peculiar and unexplainable pattern emerged of high negative readings of iodine-131 in proximity to a radiation source, in this case the nuclear reactor, surrounded by readings that diminished as distance from the plant increased.

So, was there a political purpose served by negative radiation readings? The authors write: "**These negative values would cancel the positive readings, so resulting national averages would never cause alarm**" (emphasis added). In the aftermath of a radiation release, high positive readings would be present in the environment. When these were averaged with high negative readings, the radiation in the environment could be made to magically disappear by beautiful, mathematical wizardry.

7. Key mortality data became unavailable in the aftermath of significant radiation releases. During the period of heavy fallout in the early 1960s, Massachusetts withheld information on live births, infant deaths, and total deaths. In 1970, the New York Department of State ceased its practice of publishing detailed annual listings of deaths by cause and location after evidence emerged that the incidence of leukemia had increased after fallout from the Nevada Test Site was deposited on Albany and Troy. The Connecticut Department of Health Services stopped publishing data on cancer mortality

by township, which it had done annually since the 1930s, after radiation releases from the Millstone nuclear reactor in 1975.

The few examples that have been provided do not exhaust the forgeries uncovered by Gould and Goldman. They are sufficient, however, to illustrate that mischief-makers have tampered with population statistics to befog understanding of the medical impact of radiation releases. The most disturbing implication of this revelation is that citizens are being injured unnecessarily by the government's refusal to acknowledge that low-level radiation in the environment is a hazard. In the aftermath of a radiation release, forthright disclosure of the hazards would empower people to take precautions to minimize their risk of injury. Denial and cover-up render the population vulnerable and cause otherwise preventable illnesses.

If *Deadly Deceit* were the sole source of information on these corrupted statistics, the reader might be justified in maintaining a certain skepticism. However, similar incidents have been documented by other researchers. In Wales, members of the Low Level Radiation Campaign (LLRC) forced front men in the UK nuclear industry to doctor cancer statistics in all too transparent a manner. In November of 1993, the LLRC had drawn attention to the fact that data included in the Wales Cancer Registry (WCR) showed a 300% increase in bone cancer incidence in Wales compared with the national rate throughout the UK. (Nuclear pollution in Wales and an increased incidence of cancer has been attributed to emissions of radioactivity from the Sellafield nuclear installation lying across the Irish Sea in England and to the nation's nuclear power stations. The Cult of Nuclearists in the UK hotly contests this conclusion.) The Cancer Registry responded by announcing that it would undertake a "validation" exercise of its data. In 1995, it published its revised figures. The total number of cancers were less than previously recorded, yet they still validated the conclusion of an excess incidence of bone cancer. Further, yearly variations in the Registry strongly correlated with variations in the deposition of strontium-90 released into the atmosphere twenty years earlier during the era of atmospheric weapon testing. In April 1996, amidst much publicity, LLRC convened a symposium in the House of Commons to debate the merit of Dr. Chris Busby's book *Wings of Death* and his Second Event Theory. During that meeting, a member of the National Radiological Protection Board announced that the excess incidence in bone cancers appearing in the Wales Cancer Registry no longer existed:

> By a remarkable coincidence, just two days before the Symposium, Wales Cancer Registry had announced that a second revision of the data had eliminated the excess entirely. The full report was not published for some months, fueling suspicions that the press announce-

> ment was issued to help NRPB attack Busby. By a further remarkable coincidence, on the very day of the Symposium the *Western Mail* (a Welsh daily newspaper) carried the news that WCR was to be closed amid allegations of incompetence, and its functions handed over to the Velindre NHS Trust" (LLRC 1999).

The WCR closed in 1995. In 1997, it reopened under the name of the Wales Cancer Intelligence and Surveillance Unit (WCISU). This new organization was headed by Dr. John Steward, who had written a paper exonerating the country's nuclear power stations of any blame in causing cancer. (Isn't it curious that a cancer registry is headed by a defender of nuclear power?) Soon after, it was discovered, 3,517 cases of cancer that had been included earlier in the WCR were dropped from the new database of WCISU. Missing were 18% of the total number of cases of childhood cancer among the 0-14 year olds in Wales. Further, 80% of the bone cancer cases had vanished. The alterations made in the WCISU database after their "revalidation" resulted in cancer numbers being reduced in both sexes for every year between 1974 and 1989. Mysteriously, the "revalidation", which included discovery of errors in coding and duplicate registrations, not once involved an *increase* in the number of cancers for a given year but only *decreases*. Further, the greatest revisions in any one year occurred in 1986, the year of the Chernobyl disaster. WCISU, in a feat of unparalleled prestidigitation, reconfigured the health picture of the entire population of Wales. After the third revalidation of the data of the Wales Cancer Registry within five years, the excess incidence of bone cancer in the nation miraculously disappeared along with the excess incidence of childhood cancer. Erased from the public record was evidence that Sellafield was causing excess cancers among the coastal population of Wales.

The European Committee on Radiation Risk, in its first publication, briefly cites other occurrences where data were intentionally tampered with. After Chernobyl, hundreds of thousands of people participated in cleanup operations in close proximity to the destroyed reactor and also built of a concrete sarcophagus around the reactor building to entomb the radiation for thousands of years. In subsequent years, this population of "liquidators" was reported as having a *lower* rate of leukemia than the general population. Only later did it come to light that Soviet doctors were forbidden to record this disease in their diagnoses. Scientific data was also meddled with after the fire in the reactor at Windscale in England in 1957. (This reactor was located on the site that is currently occupied by the Sellafield nuclear fuel reprocessing facility on the western coast of England.) The amount of radiation released from the fire and the incidence of cancer induced in the population of Ireland remain fiercely contentious issues. According to the ECRR, at some point after the fire, meteorological records were altered "with the apparent motive of con-

cealing the likely location of any effects." By disguising the path of the fallout plume, interested parties could minimize the perception of the risks to health in Ireland and the Isle of Man. A third example occurred in Germany after Chernobyl. Infant mortality figures were altered to mask the impact of the accident on public health.

How is the human community to discern truth from falsehood in the matter of human-generated radiation awash in the environment? How many other instances of data tampering have occurred in the last half century that have gone undetected? By its own mischief, the Cult of Nuclearists has destroyed its credibility and is ruining the trust of the people in their governing institutions. What does the public really know about the risks to health of radiation exposure? How safe are we? How accurate are the dose estimates of the survivors of Hiroshima and Nagasaki? How much radiation seeps from commercial nuclear power plants? Where does it go? Who absorbs it? How many people really became sick and died after the accident at Three Mile Island? What types of diseases in what frequency were instigated by the Chernobyl catastrophe? What impact will the detonation of nuclear weapons on the other side of the world have on the health of our children or the purity of our food supply here in the United States? How safe are depleted uranium weapons?

How will we ever be able to distinguish what is from what is not? Objective data has been falsified. Science has been compromised. Truth has been decapitated. At the hands of the Cult of Nuclearists, our minds have become the repositories of carefully crafted falsehoods and deceit. Our brains have been raped. Collectively, we have been the victims of an anthropoid ravish.

SCAM NUMBER TWENTY-TWO: Derive estimates of the risk to health from chronic internal contamination from research conducted on instances of acute external irradiation.

This point formed the basis of Exhibit C and need not be belabored. Radiation safety standards and the assessment of risk from radiation exposure are based primarily on the research of the survivors of the bombings in Japan and those who received x-ray exposure during medical treatment. In the incidents in Japan, populations were exposed to a flash, lasting a few milliseconds, of external gamma and neutron radiation. Based on the governing, *unverified* assumption that the quantity of energy delivered to tissue is the fundamental determiner of biological effect, the radiation protection agencies of the world fabricate risk estimates from these instances of acute external radiation and from them derive risk estimates for the entire gamut of possible patterns of chronic exposure from internal contamination by radionuclides. The whole basis of radiation safety is grounded on the

conjecture that there is no difference in the cellular response, the organ response, and the whole-body response between an instant of gamma exposure and chronic, repeated exposure from decaying radionuclides inside the body emitting alpha, beta, and gamma radiation. NO RESEARCH HAS EVER BEEN CONDUCTED TO CONFIRM THE VALIDITY OF THIS FUNDAMENTAL ASSUMPTION. In *Wings of Death*, Chris Busby relates an anecdote of his investigation into studies of the comparison between external and internal radiation. "When I wrote to the UK National Radiological Protection Board in 1986 asking about this, I received the reply that the board, 'knew of no studies where internal and external radiation had been compared.'"

The estimates of the risk to health from many types of chronic, low-level exposure from internal emitters is based on unwarranted assumptions. Mankind's safety from radionuclides awash in the environment is currently underwritten by fraudulent science. Risk factors may be substantially in error. Populations may be more endangered than currently believed. The radiation protection community has not done its homework.

SCAM NUMBER TWENTY-THREE: Derive the risks to health from exposure to ionizing radiation from corrupted epidemiological data.

It does not take an epidemiologist, when examining Exhibit C, to recognize that the Life Span Study of the survivors of the first atomic bombings in Japan is seriously and irreparably flawed. And yet, the radiation protection community throughout the world upholds this study as the most important source of information available to mankind on the health effects of ionizing radiation. What is going on? Something, somewhere is seriously amiss.

Of the numerous defects that compromise the Life Span Study, three stand out as fatal: 1. The dosages assigned to members of the study population are questionable guesses. 2. Between the time of the bombing and the time the study was initiated, tens of thousands of victims died of non-blast related, radiation-induced illnesses. Yet, these casualties conveniently play no part in this so-called definitive study, purported to provide reliable information of the relationship between dose and physiological response to radiation exposure. 3. The contamination of both the study and control populations with internalized radionuclides invalidates any meaningful conclusions of the incidence of disease in one population compared to the other. Clearly, by ignoring points 2 and 3, the Life Span Study is intentionally designed to deliver results that "prove" that radiation is less hazardous than it in fact is. Given its structure, it cannot help but underestimate radiation effects. It's a rigged game.

The Life Span Study is the doorway into the heart of darkness of the Nuclear Age. By it, one can catch a glimpse of the vast machinations of the Cult of Nuclearists to corrupt the science of radiation protection so it can go about its deeds unhindered. The LSS is deeply flawed science. Yet, it is lauded by the radiation protection community as a valid basis on which to erect standards of protection for all mankind. This state of affairs is appalling and remains completely nonsensical until one concedes that, yes, mischief is afoot in the science of radiation safety.

The Life Span Study has been strategically crafted as the keystone of the current myth of how the human organism responds to exposure to ionizing radiation. It is the lynchpin that holds together the corrupted paradigm of radiation effects that this chapter has been devoted to deconstructing. By the dictates of this myth, biological effect is directly proportional to the amount of energy absorbed. This energy can be treated as an abstract mathematical entity and averaged over a mass of tissue even when that tissue has not been uniformly disturbed by that energy. Whether delivered externally by x-rays or gamma rays, or internally by radioactive decay of radionuclides, dose for dose, weighting factors considered, the biological effects are the same under this model. Low-dose effects can be modelled, or extrapolated, from high-dose effects. Low doses of radiation represent no hazard to the health of the organism. And, cancer is the only endpoint of concern from radiation exposure.

The data from Japan has been erected as the "scientific" proof of this myth. It is what gives credence to current concepts of dose-response. Anointed with such legitimacy, the Life Span Study can be used to justify current emission standards from nuclear installations, the doses of radiation permitted to the public, current concepts of what risks to health accompany radiation exposure, and so forth. All of these become suspect when the results of Japan are called into question. The glaring shortcomings of the LSS testify before all humanity that the agencies setting radiation protection guidelines have been infiltrated, corrupted, and politicized and have had their scientific objectivity thoroughly compromised.

SCAM NUMBER TWENTY-FOUR: Cloak biased judgment in the guise of objectivity when selecting the data used to assess radiation risk.

When developing models of radiation risk, the radiation protection agencies use criteria that at first sight appears unassailable. They take into account only studies that have been published in peer reviewed scientific journals, and which include accurate dose-response data. How could one possibly find fault with such seemingly impeccable methodology? The concealed hoax lies buried in the words "accurate dose-response data." By

only considering instances where accurate dose information has been gathered, important avenues of investigation are precluded from consideration. For instance, many types of epidemiological studies that can offer insight on the effect of radiation releases on populations are banned from consideration when establishing risk factors because these studies do not provide data on the dosages of the exposed population. The work of Gould and Goldman, cited earlier, provides a good example. Their observation of trends in increased mortality after the arrival of Chernobyl fallout or after the accidents at the Savannah River Plant or Three Mile Island is not the type of data accepted by the ICRP for assessing radiation risk. These studies are excluded because they do not identify particular radiation victims, the dosages received by these victims, and the illnesses caused by these dosages. The same applies to the ever-increasing evidence of cancer clusters in the proximity of nuclear installations. If statistically marginal increases in cancer incidence happen in the vicinity of a single nuclear facility, this may be just an anomaly. But if marginal increases are observed around a number of installations, which is the case, the cumulative evidence becomes stronger that a link exists between the risk of developing cancer and living near a nuclear facility. Once again, this type of evidence is not considered as a basis for risk assessment. Causality must be established between an identifiable dose and an identifiable cancer victim or the work is not considered sufficiently rigorous or "scientific."

Part of the swindle of the corrupted Hiroshima data is that the dose assigned to each victim is promulgated as accurate. This is why the study is granted such importance. The problem is that, in fact, no one knows with sufficient precision the dose received by each member of the Life Span Study population. "Dose reconstruction" is based entirely on guesses and computer simulations of the geometry of the bomb, the efficiency of fission of the bomb's uranium fuel, the percentage of radiation reaching the ground, the relative contribution to dosage of gamma and neutron radiation, the degree of attenuation of the radiation field by roofs and walls that offered some margin of protection to the victims, the location and physical orientation of each victim at the instant of detonation, and so forth. All the numerous assumptions that have gone into <u>*reconstructing*</u> "accurate" dosages really make the data from Japan of questionable value. Yet, it is heralded as the definitive study for establishing dose-response in the human organism.

SCAM NUMBER TWENTY-FIVE: Deny that low doses of radiation pose a risk to health by ignoring studies that provide clear evidence that such a risk exists.

The ICRP and other agencies involved in assessing radiation risk conduct annual reviews of scientific papers published throughout the world on the biological effects of ionizing radiation. They then select from this body of work whatever data they judge as relevant to the setting of safety standards. By this means, the radiation protection agencies con-

trol the knowledge base upon which permissible levels of exposure are derived and the perception of the risks that accompany these levels. From this selective filtering, it would appear that no evidence exists for harmful effects to health caused by low levels of radiation released into the environment. But this is simply not true. The fact of the matter is that those who control the current paradigm just don't acknowledge research that intrudes into the worldview they are attempting to promulgate.

On the basis of accepted standards of safety, there was no risk to the health of the population of the United States from the fallout of Chernobyl. Similarly, releases from the accident at Three Mile Island presented no threat to the downwind population. The two previously cited accidents at the Savannah River Plant that resulted in melted fuel rods was covered up for 18 years but was no cause for alarm because, according to the Du Pont operators, "no one, on or off site, was ever harmed." Although the two reactors at the Peach Bottom nuclear power stations in Lancaster, Pennsylvania emitted fallout between the mid-1960s through 1987, these emissions were never reported as significant enough that people were warned to stop consuming dairy products from farms downwind of the facility. Similarly, the two reactors at Millstone near New London, Connecticut, were spewing inordinately large amounts of radiation into the surrounding countryside, yet the downwind population was never warned to take precautions. It is these five cases that are examined in depth by Gould and Goldman in *Deadly Deceit*. In spite of the mischief uncovered in Scam Number Nineteen, the authors found sufficient statistical data to confirm elevated incidences of infant mortality and total mortality in the exposed populations in the aftermath of these releases. The inexcusable tragedy is that a timely and forthright disclosure could have reduced mortality and cancer incidence among the unsuspecting populace. People could have taken precautions. But if these hazards had been admitted, the admission would have amounted to a confession of the danger of the technology and the inadequacy of current radiation standards to protect the public from low-level radiation-induced illness.

Gould and Goldman make an important observation in the conclusion of their book:

> Any individual case that passes a significance test may still reflect a random variation. But the cumulative significance of the five sets of correlations between low-level radiation and increased mortality, considered in Chapters Two, Four, Five, Eight, and Nine, means that the likelihood that they are all chance occurrences is remote.

This is a rebuttal to those nuclear apologists who insist that insufficient data exist to

demonstrate low-level radiation effects in populations. Although individual studies may be inconclusive, the cumulative significance of observed correlations across a number of studies strengthens statistical probability. Gould and Goldman provide an excellent example in data they collected in the aftermath of Chernobyl. The accident occurred on April 26, 1986. Starting on May 5, radiation-monitoring stations in Washington State began recording elevated levels in rainfall of iodine-131, a product of nuclear fission. Peak values were recorded between May 12 and May 19. This provided evidence that Chernobyl fallout had reached the United States. Starting on May 16, 50 EPA milk-monitoring stations in states that received rain mixed with fallout began recording elevated levels of iodine-131 in milk. "No warnings against drinking the milk were issued by public health authorities because the reported levels were regarded as safe" (Gould and Goldman). These elevated radiation readings correlated with government data of increased mortality throughout the United States for the month of May: "The higher the level of radioactive iodine found in milk in a region, the higher the percent increase in total deaths." Elaborating on these facts, Gould and Goldman offer this observation:

> These statistics showed a surprising 5.3 percent increase in the total number of deaths in the US in May 1986 over the same month in the previous year. This was not only statistically significant (with a probability of less than one in a thousand of being a chance event); it was, in fact, the highest annual increase in May deaths recorded in the US in 50 years. There were also high percentage increases in deaths in the three succeeding months.

A graph comparing levels of iodine-131 in milk with increases in mortality yield evidence for the Supralinear Hypothesis, namely, that increased risk occurs at low doses and the rate of mortality diminishes as doses increase. The graph "indicates that deaths increase rapidly with iodine-131 levels below 100 picocuries per liter, but the percentage increase flattens out at higher radiation levels." According to Gould and Goldman:

> If the Chernobyl fallout is responsible for these steep and highly unlikely mortality increases, then this is the first evidence using large populations that suggests the dose-response curve at very low dose rates of fallout radiation exposure is logarithmic and not linear, contrary to generally accepted assumptions. The medical and scientific community has long believed, on the basis of linear extrapolations from high doses, that low-level radiation from fallout and nuclear plant releases can be dismissed as posing a negligibly small danger. The Chernobyl experience indicates that this assumption may underestimate the effect of low radiation doses for the most sensitive members

of the population by a factor of about one thousand.

To strengthen their conclusion that Chernobyl fallout caused an increase in mortality, Gould and Goldman provide evidence of unprecedented levels of bird deaths reported by Dr. David DeSante, a researcher at the Point Reyes Bird Observatory in California. In a letter by Dr. DeSante, the following observation was made:

> We documented a massive and unprecedented reproductive failure of most species of landbirds at our Palomarian Field Station [located 25 miles north of San Francisco] during the summer of 1986. The number of young [newly hatched] birds captured in our standardized mist-netting program was only 37.7 percent of the previous ten-year mean. Interestingly, the reproductive failure did not begin at the start of the breeding season but only after about one month of the season had passed, that is, for birds hatched about mid-May. Furthermore, there seemed to be a slight recovery of reproductivity very late in the season. Might this implicate iodine-131? (Gould and Goldman)

To further strengthen apparent correlations between Chernobyl fallout and increased mortality, *Deadly Deceit* provides evidence of increased levels of infant mortality in West Germany during the same period in areas contaminated by fallout. The authors then conclude that "the probability that the simultaneous mortality peaks in the US, West Germany, and among birds are unrelated random events can be expressed mathematically as one out of 10^{30}"

Again, the reader must ponder why the radiation protection community continues to rely on the politically corrupted Hiroshima data to establish the risks of radiation exposure when other data is available. Gould and Goldman argue that the worldwide data from Chernobyl can provide accurate risk assessments for low-level radiation exposure for the following reasons:

1. It involves a much larger exposed population than any other study.

2. It involves a normal population, not hospital patients, workers of a limited age range of 18-65, or war survivors of a traumatic bombing.

3. It involves extremely low doses, cancelling the need for uncertain extrapolations from higher doses.

4. It involves accurately measured amounts of radioactivity in the diet over a wide range

of concentrations made by monitoring stations throughout the world. "No such accurate measures of dose were available in any earlier studies of environmental radiation exposures or direct radiation exposure at Hiroshima and Nagasaki."

5. It involves internal radiation exposure.

Gould and Goldman summarize their argument concisely: "Thus, the statistics emerging from the Chernobyl disaster permit, for the first time ever, the establishment of a dose-response relationship at extremely low doses in a normal human population." Those people who endorse programs that result in the liberation of radioactivity into the environment will violently argue against this conclusion. It flies in the face of their efforts to marginalize the disastrous public health consequences of Chernobyl. It intrudes on their claim that low-level radiation is without effect. It etches away at their prejudiced assumption that Hiroshima is the disaster of choice for understanding radiation effects in man.

SCAM NUMBER TWENTY-SIX: Underestimate the risk of damage to cells from low-level radiation by making the false comparison between normal free radical damage and damage caused by ionizing radiation.

Routinely, an enormous number of free radicals are produced in cells, and these induce molecular damage to DNA and other important cellular structures. Exposure to ionizing radiation creates a much smaller number of additional free radicals. Based on these facts, those who deny the hazard of low-dose radiation make the argument that since cellular mechanisms routinely repair naturally occurring free radical damage, they obviously have the capacity to repair damage induced by ionizing radiation. This is a seductive and seemingly convincing argument. However, as John Gofman points out, it is based on two false assumptions: "(1) that the nature of damage done by ionizing radiation is the same as the nature of damage done by routine metabolic free radicals, and (2) that damage therefore can be compared by comparing the relative numbers of free radicals" (Gofman 1997).

Gofman demolishes these two assumptions in his article, "The Free-Radical Fallacy about Ionizing Radiation: Demonstration that a Popular Claim is Senseless". His argument runs as follows: By some estimates, the DNA of each cell in the body is exposed to between 120,000 and 240,000 damage events per day from intrinsic metabolic processes. In response, cellular mechanisms are rapidly activated that repair this damage. If the damage caused by radiation is not qualitatively different from normal free radical damage, which is the basic assumption of the Free-Radical Fallacy, then repair mechanisms should have the capacity of undoing an equivalent amount of damage produced by ionizing radiation. Can this be the case? Gofman's response is as follows. Understanding exists as to

the repair capacity of the human organism. Estimates exist for the number of damaging events produced in each cell by each rad of absorbed dose. Further, experiments have confirmed that, in response to whole-body radiation of 100 rads delivered all at once, human cells mobilize a sufficient amount of repair enzymes to repair all genetic damage. In fact, repair capacity is not overwhelmed by the number of damaging events induced by 500 rads. Thus, the body has the capacity for perfect repair. However, a dose of many hundreds of rads is a lethal dose. Thus, perfect repair is not the central issue in the body's ability to withstand radiation injury. From this simple thought experiment, Gofman arrives at the conclusion that either the nature of the damage caused by ionizing radiation or the nature of the repair process cannot possibly be the same for the oxidative damage of normal cellular processes and that caused by ionizing radiation. Gofman continues with the argument that repair capacity is not the issue, but that radiation damages cellular structures in complex ways that resist perfect repair. [Double-strand breaks to DNA are an example of complex damage compared to the more usual single-strand breaks caused by normal free radical damage.] Gofman states:

> The difference between free-radical damage from routine metabolism and from ionizing radiation almost surely lies in repairability. If DNA damage is perfectly repaired by a cell, such damage has no health consequences. It is inconsequential. The consequences arise only from injuries which are non-repairable or mis-repaired.
>
> The power of ionizing radiation to induce particularly complex and unrepairable genetic injuries is surely related to a unique property of this agent. Ionizing radiation instantly unloads biologically abnormal amounts of energy at random in an irradiated cell. Biochemical reactions in a cell generally involve net energy-transfers in the ballpark of 10 electron-volts and below. By contrast, Ward reports that the average energy-deposit from low-LET ionizing radiation is thought to be about 60 electron-volts, all within an area having a diameter of only 4 nanometers. (The diameter of the DNA double-helix is 2 nanometers). In other words, ionizing radiation produces violent energy-transfers of a type simply absent in a cell's natural biochemistry.
>
> Because of its unique property, ionizing radiation is a unique menace to our DNA and chromosomes. This fact needs wide recognition, as mankind learns that far more health problems are mutation-based than anyone could prove 15 years ago.

SCAM NUMBER TWENTY-SEVEN: Underestimate the risks posed by low-level radiation by failing to take into account known physical and biological phenomena.

According to the model of risk assessment upheld by the ICRP, the density of ionization events within a target mass is the key determinant of biological effect. To account for the fact that the same quantity of energy will create different patterns of ionization depending on whether it is delivered by alpha, beta, or gamma radiation, the equations of the ICRP allow for the introduction of a weighting factor to make allowance for these differences, called the *radiation weighting factor*. As an example, if the equivalent dose of radiation is delivered to a tissue by x-rays and alpha particles, the biological effect of alpha particles is weighted as 20 times greater than that produced by the x-rays due to the denser pattern of ionization (more destruction per unit length along a track of alpha particles.) A second weighting factor is added to calculations: the *tissue weighting factor*. This mathematical expression is inserted into equations to capture the differing sensitivities of the various organs of the body, and to offer an expression for the contribution of each organ to total health detriment resulting from uniform external irradiation to the whole body. The addition of the two weighting factors into the complex modeling of the ICRP is an attempt to create a realistic model that connects the quantity and quality of radiation to the probable biological effects. Unfortunately, the model is archaic. It fails to take into account known physical and biological phenomena that add to the hazard of the organism. This conveniently leads to an underestimation of risk.

To address these shortcomings, the European Committee on Radiation Risk proposes that, to salvage the ICRP methodology from irrelevance, additional weighting factors need to be included in calculations to address current understanding. (It must be emphasized that the ECRR has absolutely no influence at this point in time over the methodology of the mainstream radiation protection community. Their suggestions can easily go unheeded, and the ICRP and related organizations can continue to ignore biological realities in their questionable risk assessments. Of course, such intransigence will only further weaken their credibility.) To fully capture the hazard to the organism posed by radiation, the ECRR sees the need for the addition of a *hazard enhancement weighting factor*. This would inject into calculations known physical and chemical effects that at this point in time are completely overlooked by the ICRP. A few examples will be given to illustrate current shortcomings in the accepted methodology that lead to an underestimation of the hazard to health from low-level radiation.

1. Radioisotopes which gain access to the interior of the human body behave in accordance with their chemical composition. Thus, different radioisotopes pose different hazards depending on how they migrate through the human body and where they are

retained. It has been proven that isotopes of strontium, barium, and plutonium have a propensity to bind to DNA. Due to their intimate proximity to DNA, the likelihood is increased that these radioisotopes will induce irreparable genetic damage. The ECRR recommends acknowledging this increased hazard in comparison to other radioisotopes that don't bind to DNA inside the body. This observation is important when discussing the hazards created by the inhalation of depleted uranium. It has been observed that uranyl UO_2^{++} ions bind strongly to DNA (Wu). As a consequence, internalized uranium poses enhanced hazards that are totally ignored by all agencies.

2. Cells have a range of sensitivity to radiation depending on where they are in the cell cycle, but this variation in sensitivity is not considered in risk assessment. Cells undergoing replication are more sensitive to radiation effects than cells which are not in the process of cell division. This can enhance radiation effects under certain circumstances. "For external low LET radiation there is a 600-fold variation in the sensitivity for cell killing over the whole cell cycle" (ECRR). Take the example of two separate doses of external radiation delivered in a 24-hour period. The first dose will induce some portion of the targeted cells to initiate cell repair and replication processes. Once these are underway, a second dose hitting them in this heightened phase of sensitivity will be more hazardous than if the second dose were delivered after the cell population had returned to stasis. Second Event theory postulates a similar phenomenon for certain types of internal emitters. For instance, an atom of strontium-90 may be bound to a chromosome. When it decays to the radioisotope yttrium-90, it will produce a track of ionization through the cell that may produce sublethal damage. This may signal the cell to enter a repair-replication sequence. Yttrium-90 has a half-life of 64 hours. Consequently, a probability exists that it will undergo decay during the phase of enhanced sensitivity of the reproducing cell, when DNA damage can no longer be repaired. Conditions at this point are ripe for irreparable mutations to be created that, if not lethal, will be passed on to all descendants of the daughter cells created from the original cell division. The ECRR recognizes increased hazard in the two scenarios mentioned here and proposes increased weighting factors in calculations of risk under these conditions.

3. Certain types of insoluble hot particles lodged in tissue represent a hazard that is not addressed by current estimates of risk. The biological effect of this type of contamination depends on the size of the embedded particle, the activity, and the dose. Being insoluble, these particles may remain lodged in their place of deposition for long periods of time. As such, they represent an enhanced hazard to surrounding cells when compared to single atoms of the radionuclide dispersed throughout greater volumes. The ECRR believes that this phenomenon warrants inclusion in determinations of risk from internal emitters.

The first publication of the ECRR contains a deep discussion of the ICRP model, its shortcomings and recommendations for bringing it into harmony with current knowledge of radiation effects. The work of the ECRR, however, sets it on a collision course with the nuclear establishment. When applying its risk factors to estimates of health detriment following exposure, radiation is revealed to be much more hazardous than currently assumed. For instance, the risk factors (the probability of injury) per sievert for whole populations for whole-body effects is double that of the ICRP for fatal and nonfatal cancers, severe hereditary defects, and cancer and severe retardation after in utero exposure.

SCAM NUMBER TWENTY-EIGHT: When establishing risks to health from ionizing radiation, ignore scientifically validated low-dose effects that inconveniently intrude on the reigning scientific paradigm.

The mainstream radiation protection community does not acknowledge that low-level radiation delivered at a slow rate poses a hazard to public health. They are only able to sustain this position by sacrificing objectivity and ignoring scientifically validated low-level effects. Their position is aptly summarized by Rosalie Bertell:

> In the official approach to radiobiology, only direct damage to DNA has been recognized as "of concern," and only high-dose/fast-dose rate experiments or observations have been accepted for use in estimating the dose-response rate. As was noted, it is the "common wisdom" that effects of low doses/slow-dose rates cannot be studied, but must be extrapolated from the officially accepted high dose/fast-dose rate studies. Basing one's theory on claims that it is impossible to study the phenomenon is certainly a peculiar way to do science! (Bertell 1999)

Actually, important low-dose effects involving other than DNA damage have been confirmed by repeated experimentation. One such biological mechanism that has received a great deal of attention is the Petkau Effect. This phenomenon was first discovered by Dr. Abram Petkau, a Canadian physician and biophysicist, who at one time managed the Medical Biophysics Branch of the Whiteshell Nuclear Research Establishment in Pinawa, Manitoba. In 1971, Dr. Petkau was studying the effects of radiation on model lipid membranes extracted from fresh beef brain. In an early series of experiments, he determined that when delivering an x-ray dose of 26 rads per minute, a total dose of 3,500 rads was required to destroy a cell membrane in an aqueous solution. Altering his procedure, he added to the water a small quantity of sodium-22, a commonly found radionuclide in fallout and releases from nuclear reactors. Under these new conditions, the cell membranes were receiving the minuscule dose of 0.001 rads per minute. Quite unexpectedly, the cell

membrane was destroyed by a total dose of only 0.7 rad. Dr. Petkau had unveiled some biological phenomenon that occurred when cell membranes were exposed to low doses of radiation delivered at a slow rate that was absent when the membranes were exposed to high doses delivered at a fast rate. Further experimentation explained what was happening. When exposed to x-rays or radioactive decay of sodium-22, electrons were liberated into the aqueous solution and captured by dissolved oxygen. The result was that free radicals were formed. These negatively charged free-radical molecules were then attracted to the electrically polarized cell membrane. On encountering the cell membrane, these molecules would initiate a chemical chain reaction that dissolved the lipid molecules of which the membrane was principally composed. The leaking, compromised cell membrane, if not repaired, would initiate cell death. What made the low numbers of free radicals created by the radioactive sodium so much more efficient in producing this effect than the large numbers created by the x-ray exposure was their unimpeded access to the cell membrane. They tended not to interfere with one another, and so had a much higher probability of reaching and interacting with the cell membrane. It had been discovered that the slight electrical charge of the cell membrane attracts free radicals when they are present in low concentrations. With more free radicals present, the attraction weakens. With the high dose x-ray exposure, the massive numbers of free radicals became so concentrated that they tended instead to interact with one another forming ordinary oxygen. Their abundance actually reduced their ability to reach the cell membrane. A simple analogy suffices to explain the phenomenon:

> Think of the free radicals as individuals in a crowded room. A fire starts and everyone tries to get out at the same time. As a result, everyone bumps into each other and very few escape. If only a few people are in the room when the fire occurs, however, everyone leaves easily through the door. The rate of escape is very high, and therefore, efficient (Gould and Goldman).

The Petkau Effect cannot just be swept under the table and ignored by those assessing the risks of radiation exposure. It is a verified phenomenon which may explain the hazards posed by low doses of internal emitters. Further, it provides evidence that DNA damage and cancer are not the only endpoints of concern from radiation exposure, that cell membrane damage may affect every cell line in the body. This drastically alters the current picture of how radiation exposure can compromise health:

> Chronic exposure to low-level radiation produces only a few free radicals at a time. These can reach and penetrate the membranes of blood cells with great efficiency, thus damaging the integrity of the entire immune system although very little radiation has been absorbed.

> The correlations of health effects with low-level radiation may thus be caused indirectly by chronic low-level exposures to ingested radiation through hormonal and immune system damage from free-radicals. Low levels of strontium-90 and iodine-131 ingested in food, milk, and water, and breathed in air, may damage the ability of the body to detect and destroy infected or malignant cells. Such damage may occur even if radiation is present at concentrations far below existing standards. These standards were set on the basis of a quite different biological mechanism: cancer cell production caused by the direct impact on genes of high doses of external radiation (Gould and Goldman).

In her writings, Rosalie Bertell has mentioned two other unexpected effects to low-dose/slow-dose rate exposure to ionizing radiation that can be attributed to other biological mechanisms than direct damage to DNA. These involved monocyte depletion and deformed red blood cells. According to Bertell (Gulf War Syndrome, 1999):

> Monocyte depletion: Nuclear fission produces radionuclides which tend to be stored by humans and animals in the bone tissue. In particular, strontium-90, plutonium and the transuranics have this property. Stored in bone, near the stem cells which produce the white blood cells, these radionuclides deliver a chronic low/slow dose of radiation which can interfere with normal blood-cell production. A few less neutrophils or lymphocytes (the white blood cells which are most numerous, and are usually "counted" by the radiophysicist) are not noticeable. In the normal adult, there are about 7,780 white cells per microlitre of blood. Of these, about 4,300 are neutrophils and 2,710 are lymphocytes. Only 500 are monocytes.
>
> If, for example, stem cells in the bone marrow are destroyed so as to reduce total white blood count by 400 cells per microlitre due to the slow irradiation by radionuclides stored in the bone, this would represent a depletion of only five percent in total white cells, an insignificant amount. If all of the depletion was of neutrophils, this would mean a reduction of only 9.3 percent, still leaving the blood count well in the normal range. The lymphocytes would also be still in the normal range, even though they were depleted by 400 cells per microlitre, or 14.8 percent. However, there would be a dramatic depletion of the monocytes by 80 percent. Therefore, at low doses of radiation, it is more important to observe the monocytes, than to wait for an effect on the lymphocytes or neutrophils (as is now usually done).

The effects of serious reduction in monocytes are:

- Iron deficient anemia, since it is the monocytes which recycle about 37-40 percent of the iron in the red blood cells when they die;

- Depressed cellular immune system, since the monocyte secretes the substance which activates the lymphocyte immune system.

Deformed red-blood cells: Dr. Les Simpson, of New Zealand, has identified deformed red-blood cells, as observed under an electron microscope, as causing symptoms ranging from severe fatigue to brain dysfunction leading to short-term memory loss. He has identified such cells in elevated number in chronic fatigue patients, and speculated that because of their bloated or swollen shape, they are obstructed from easily passing into the tiny capillaries, thus depriving muscles and the brain of adequate oxygen and nutrients. The chronic fatigue syndrome has been observed both at Hiroshima and Nagasaki, called bura bura disease, and at Chernobyl (Bertell 1993).

SCAM NUMBER TWENTY-NINE: Base estimates of risk to a population from exposure to radiation on the response of the average adult while ignoring the heightened sensitivity of subgroups within the population.

As currently crafted, risk estimates are inherently flawed. They are based on average exposures to average individuals. Permissible levels of exposure are then set on the presumption that these will protect the entire population from radiation injury. This approach fails to take into account the fact that populations are heterogeneous, and that subgroups exist within the population that have heightened sensitivity to radiation effects. We know from studies done on patients undergoing radiation therapy that individuals can differ considerably in their sensitivity to radiation. A number of genetic syndromes have been identified that predispose individuals to heightened risks of various forms of cancer. Enhanced radiosensitivity is frequently connected with two phenomena: 1) deficiencies or disturbances in DNA repair after radiation damage, and 2) an uncontrolled proliferation of cells due to faulty regulation of arrest of the cell cycle (Streffer). Currently, no accurate information exists as to the percentage of such genetically predisposed radiosensitive individuals within the general population. Published estimates vary from one to six percent.

The statistical studies of Gould and Goldman, as reported in *Deadly Deceit*, uncovered an interesting trend in the wake of the Chernobyl disaster. In the months immediately following the arrival of the fallout cloud over the United States, the increased mortality

that was recorded was not uniformly distributed throughout the US population. Rather, elevated rates of death were most in evidence among infants, young adults suffering infectious diseases, and the elderly. Their recorded causes of death were predominantly pneumonia, infectious diseases, and AIDS. The authors hypothesize that it was vulnerable immune systems further stressed by radiation that was the mechanism responsible for the increased mortality.

Radiation protection standards, if their purpose is to protect people, must be written so as to protect the most sensitive sector of the population from harm. This would then ensure the maximum level of protection for everyone. Most importantly, the health of developing fetuses must be protected by standards that restrict the level of internal contamination in pregnant women. If such a concern is disregarded and standards are written merely to protect the "average" citizen, whoever that might be, then the most sensitive segment of the population is being exposed to much greater risks than current estimates would have us believe. As the ECRR observes: "Once we take into account varying radiosensitivity in the population it is difficult to think of a morally acceptable alternative to developing risk models that are based on the health risks of the most susceptible citizens."

SCAM NUMBER THIRTY: Use current theories of cancer etiology as a multistage process to deny that exposure to low doses of radiation is hazardous.

In 1927, Hermann Muller published his research on x-ray induced mutations in populations of male fruit flies. In the course of his investigations, Muller observed that the frequency of mutations was directly proportional to the dose, and that no-threshold dose existed for the onset of genetic damage. With decreasing dosages, the frequency of mutations decreased, but they did not entirely cease to occur. No dose, however small, was found to be 100% risk-free for genetic damage. This discovery was the historical foundation for what later developed into the Linear No-Threshold Hypothesis for cancer induction. The rudiments of this hypothesis and its implications for the standards of radiation safety first appeared in Publication 1 of the ICRP in 1958. Further articulation of the hypothesis appeared in ICRP publications in 1962 and 1965. In 1991, for the purpose of radiation protection, the ICRP officially endorsed the LNT Hypothesis.

A vocal opposition has always questioned the validity of the LNT Hypothesis. Gunnar Walinder made the following observation in an article that ended with the remark, "the LNT hypothesis is one of the greatest scientific scandals of our time." As he went on to say:

> However, there were many people who were reluctant to accept the

> new idea of the LNT. Rolf Sievert found it difficult to reduce complex biological phenomena such as heredity and cancer to a straight line. He simply did not believe in stochastic, biological effects and his arguments were very similar to those later expressed by Lauriston Taylor. The same opposition could also be found among the oncologists at Radiumhemmet in Stockholm, of whom the perhaps most eloquent spokesman was Dr. Lars-Gunnar Larsson. They claimed that the drawing of straight lines has nothing to do with biology and such methods could never constitute a model of a biological process and, least of all, the complex kind of dysdifferentiation that we call cancer.

Walinder continues with an interesting observation about the shortcomings of a linear mathematical model for cancer rates within populations.

> The basic doctrine in the radiation protection is expressed (after low doses and dose-rates) by the simple formula: N = 0.05 x D where N is the number of radiogenic cancer cases and D is the collective dose (expressed in manSv). This formula is considered valid for all populations and independent of living habits and other factors that normally are considered of significance for tumor formation. Advocates of this equation cannot possibly have any knowledge of the generic category of disparate diseases which we have given the common name cancer. Nor can they have any idea about the epistemological prerequisites for using mathematical models. As a physicist, I have, of course, always applied mathematics to my problems. However this mathematics has to be adjusted to the specific task. To me, it is impossible to understand how one and the same formula can be used as a collective model for all disparate forms of cancer. How should we explain the fact that various forms of cancer have different dose-response relationships and that some tumors cannot, on the whole, be induced by ionizing radiation (for example, such common forms as the uterine cancer and those in the prostate). How can anyone believe that such extremely complex processes as the general carcinogenesis can be adequately described by an equation of the first degree? This model obviously does not fulfill any demands for consistence or generality. The formula is not only generally considered valid, it is also said to be applicable at "homeopathic" radiation doses. What an unbelievable pretension to knowledge: "We know everything and we are able to give quantitative figures of infinitesimally small radiation risks." It reminds me of Moliere's comedies. Could we not hope that, in a reasonably short future, such pretensions of knowledge will give rise to the same roar of laughter as is the case with the precious figures

> in Moliere's comedies? In no other scientific field have such deeply unscientific claims been made.

Today, the steps leading from radiation-induced genetic alteration to the expression of cancer in the organism are mired in controversy. Many researchers believe that the popular idea of a single cell being transformed into a malignant state in one step is overly simplistic. Evidence has accumulated that the initiation of cancer is most likely a multistage process. As the ECRR notes: "As a result of examining the variation of cancer rates with age, cancer is now believed to be the result of up to six separate genetic changes. These include acquisition of specific oncogenes and loss of tumor suppressor genes." The onset of uncontrolled cell proliferation is further impeded by a number of biological defense mechanisms that intercede at an early stage to repair radiation damage or prevent an altered cell from reproducing. These defense mechanisms include such things as immune system removal of cells with persistent DNA alterations, enzymatic reactions, apoptosis (suicidal elimination of altered cells), activation of tumor suppressor genes, cell cycle regulation, and various intercellular interactions. On the basis of this repair capacity and the complex, multistage process of cancer etiology, many researchers advocate that radiation protection standards need not be as stringent as they are today. They hypothesize that the human organism can tolerate greater levels of exposure than permitted today without undergoing ill effects. The body has a generous capacity for eliminating the effects of low-dose radiation before such effects induce cancer.

The conclusion of this line of reasoning is succinctly stated by Walinder:

> Modern oncology has also clearly shown that the transformation of a cell into a malignant phenotype is a multistep process that demands several changes in different parts of the genome. All these changes cannot be caused by a low radiation dose. Thus, here too, the malignant contribution of the radiation is dependent on the presence or future emergence of other, necessary genetic effects.

The complexity of cancer etiology is becoming an increasingly popular theme of nuclear apologists intent on loosening standards for radiation protection. However, those who advocate that low levels of radiation cannot possibly induce cancer and that regulation of low levels of exposure is unnecessary fail to see that their argument is deeply flawed and reckless. With cancer being a multistage process, it is reasonable to assume that some unknown percentage of a population carries within its cells precancerous genetic alterations from any number of environmental or hereditary sources. In these people, exposure to even low levels of radiation may be sufficient to induce that final genetic mutation neces-

sary to ignite a malignant proliferation of cells. Even with cancer understood as a complex, multistage process, low-level radiation, being a mutagen, must be considered hazardous. The ECRR makes this point perfectly clear:

> The outcome of radiation exposure in the exposed individual follows the effects of somatic damage to cells. In the case of cancer as an outcome, there is seen both an immediate effect and a delayed effect. This pattern of risk with time is a consequence of the multistage etiology of cancer. Cancer is now believed to result from the accumulation of genetic damage in cells or their descendants. The particular pattern of incidence of cancer with age is most easily explained by assuming that a geometric increase in the number of a damaged cell clone ultimately results in a high enough probability that one of the cell descendants will acquire a second or subsequent necessary genetic mutation for cancer to develop in that cell (or group of cells). It follows that an exposure episode may either cause initial genetic damage in cells which have none or add to genetic damage which is already present. For those cells which have already acquired the initial set of genetic damage, the exposure may produce the final requirement for cancer. For undamaged cells the episode will supply the initial damage and start the process [emphasis added].

In summarizing the current theory of the etiology of cancer, Lars Persson of the Swedish Radiation Protection Institute makes the same point:

> Neoplastic initiation encompasses the irreversible cellular damage, which provides the potential in cells for neoplastic development. There is good evidence that this initiation process results from damage to DNA leading to gene or chromosomal mutations in single cells in tissues. The critical event in relation to ionizing radiation is likely to be DNA double-strand breaks for which error-free repair is not likely at any dose.
>
> Once the necessary gene mutation is present in a cell, further neoplastic development is believed to be highly dependent upon the cellular environment. Promotional events, influenced by growth factors in cells, dietary constituents, hormones, or other environment agents, may increase cell proliferation and may, in some instances, interfere with communication processes between cells that act to maintain cellular stability in tissues.
>
> Conversion of these pre-neoplastic cells to a form in which they are committed to be malignant is believed to be driven by further gene

> mutations.
>
> Progression of the disease, once the potential for a malignancy has been established, may depend upon further cellular changes that allow for the invasion of adjacent normal tissues, the circulation of neoplastic cells in the blood and lymphatic systems and the establishment of metastases at other sites in the body.
>
> Radiation-induced mutations may influence all stages of the neoplastic process. Consequently, at the level of DNA damage, there is no basis for assuming that there is a dose threshold below which the risk of tumor induction is zero.

The bottom line is that radiation, at any level of exposure, poses a hazard to the health of some portion of the population. Arguments that try to deny this fact are ill-conceived and politically motivated. Low-level radiation can be responsible for initiating the first step of a multistage process or for tripping precancerous cells into the final stage where malignancy commences. This is a plausible mechanism for explaining elevated incidences of cancer among populations exposed to low levels of radiation released from nuclear installations. Our theories of cancer may change, but they cannot repudiate the capacity of ionizing radiation to structurally alter DNA, and thus, be a mechanism in the process of carcinogenesis.

SCAM NUMBER THIRTY-ONE: When assessing the health risks of particular radioisotopes, make invalid comparisons between the health effect of the isotope as it is found in nature with the health effect of the technologically enhanced form of the isotope.

The defenders of depleted uranium weapons are guilty of a gross scientific gaffe. They proclaim that these weapons pose no radiological hazard, and they substantiate their claims by citing research on the health effects of the uranium-found-in-nature on uranium miners, uranium millers, and other populations of workers in the uranium fuel cycle. What these proponents conveniently fail to mention is that no body of scientific research exists to prove that their comparison is valid. They presume, without proof, that inhaling the dust of ore in which uranium exists in low concentration has the same biological impact as inhaling minute particles of pure uranium metal contaminated with small quantities of fission products. (A fuller discussion of the make-up of DU weapons can be found in the chapter *Are Uranium Weapons Made of Uranium?*) It has never yet been proven that the physiological response of the human body to the two forms of uranium is the same. Thus, it is presumptuous and unscientific to proclaim that depleted uranium weapons pose no risk to health. Yet this fallacy of relying upon studies of the health effects of the uranium-found-in-nature

to acquit uranium munitions of being a radiological hazard has been used in reports authored by the National Research Council, the Rand Corporation, the Royal Society in the UK, the European Commission, the European Parliament, and the World Health Organization. How can all these institutions make the same simple procedural error in their research protocols? The debate over the safety of nuclear and radiological weapons has little to do with biology and everything to do with what you can get away with in the court of public opinion.

SCAM NUMBER THIRTY-TWO: When all else fails, simply lie.

Spokesmen for the US military profess tirelessly, to all who will give them ear, that depleted uranium weapons pose no radiological hazard to health. In making such statements, they contravene safety guidelines openly endorsed by other government agencies. The Federal Aviation Administration's Advisory Circular 20-123, written December 20, 1984, bears witness to this embarrassing contradiction. That memo, authored by M.C. Beard, Director of Airworthiness, is entitled "Avoiding or Minimizing Encounters With Aircraft Equipped With Depleted Uranium Balance Weights During Accident Investigations." The warning contained therein was directed to airline crash-site investigators who inadvertently might be exposed to depleted uranium amidst the wreckage of destroyed commercial airplanes. Caution was urged due to the fact that aircraft manufacturers had begun routinely to utilize depleted uranium coated with cadmium plating to balance ailerons, rudders and elevators on certain jet aircraft, and rotor blades on certain helicopters. The advisory contained the following warning:

> While the depleted uranium normally poses no danger, it is to be handled with caution. The main hazard associated with depleted uranium is the harmful effect the material could have if it enters the body. If particles are inhaled or digested, they can be chemically toxic and cause a significant and long-lasting irradiation of internal tissue (FAA).

Following this warning, the recommended precautions were delineated: .

> a. Avoid contact with balance weights using depleted uranium. On arrival at accident scenes of aircraft suspected of containing balance weights made of depleted uranium, determine if balance weights have been damaged or lost their cadmium plating coating. Request specialized assistance if balance weights have been damaged or lost their cadmium plating. No penetration of the plating is allowed.

> b. Avoid breathing or swallowing particles of balance weights found damaged or with cadmium plating damaged or lost.
>
> c. If it becomes necessary to handle balance weights, the following precautions should be observed.
>
> (1) Personnel handling the balance weight should wear gloves.
> (2) Industrial eye protection should be worn.
> (3) Respirator mask should be worn to ensure no radioactive dust particle ingestion.
>
> d. Gloves, wrapping material, wiping cloths, respirator filters, or any other articles used in the handling of damaged balance weights should be discarded and appropriately labeled as radioactive waste and disposed of accordingly.

Clearly, depleted uranium is identified in this circular as radioactive waste that poses a threat to health. And yet, this same radioactive waste is freely dispersed across the modern battlefield where our own soldiers and those of our allies, enemy combatants and civilians are left vulnerable to hazardous internal contamination. They are denied the luxury of calling for "specialized assistance." In most instances, they are not forewarned to protect themselves with gloves, eye protection and respirators or lack such specialized knowledge and equipment. They have no opportunity to regather the radioactive dust liberated from a tank kill and package it in red containers to identify it as radioactive waste. Rather, it is set free in the environs to be deposited in the tissues of living creatures where it will irradiate their cells. Circulating through the environment via wind and water, the DU dust will remain a hazard to life for billions of years.

While on the subject of lies and liars, it would be informative to rehearse some of the statements made in Kiev in 2001 at the second World Health Organization conference on the health effects of Chernobyl. Abel Gonzalez of the International Atomic Energy Agency, with shameless audacity, stood before a room of eminent Russian and Ukrainian scientists and spouted the following drivel:

> The known effects of the Chernobyl accident are 31 deaths in liquidators and 200 thyroid cancers in children. Whether any other effects have occurred is an epistemologically insoluble problem, we just don't know. There are no other internationally agreed effects (CERRIE Minority Report).

Lending two part harmony to this mockery to intelligence, Norman Genter of UNSCEAR stepped to the microphone and chimed in:

> The risk of leukemia does not seem to be elevated even in the liquidators. I agree with the IAEA, positive perspectives exist. For those who believe, no explanation is necessary; for those who do not believe, no explanation is possible. We use the most rigorous possible data so that the people and the decision makers can get the right information (CERRIE Minority Report).

Incensed by these malicious fairy tails, Professor Alexey Yablokov, a member of the Russian Academy of Sciences and an advisor to Presidents Gorbachov and Yeltsin on environmental issues, rose and bellowed the following admonition:

> This is Shocking, Shocking! An impudent presentation of nonobjective data. What scares me is it's said openly, presented as scientific conclusions. There were irremediable falsifications of official health data. Don't you know that the leaders of the State Committee for Statistics were arrested two years ago for falsifying data. UNSCEAR knows it. They know the data were falsified! They use these to say that the consequences of Chernobyl were not so serious. They say there are no genetic effects after Chernobyl, but the genetic effects are the most serious. Tens of papers in serious scientific journals show this. Bandashevsky shows the effects in children, sudden deaths, organ damage. Increases in mortality, cancers, congenital malformation, immune system disorders, exhaustion, slow growth. How is it possible to reject this? Silencing these facts is incorrect. It is science (CERRIE Minority Report).

SCAM NUMBER THIRTY-THREE: Cloud thinking on the biological effects of human-generated low-level radiation with the claim that populations living in areas of high Natural Background Radiation are no more at risk from radiation-induced injury than people living in areas of low Natural Background Radiation.

Those who claim that emissions of radiation into the environment are harmless hold in their hand one seemingly unbeatable trump card. If low doses of radiation are hazardous, they argue, then people living in areas of high Natural Background Radiation should suffer from higher rates of cancer than people living in areas where NBR is low. The central importance of this argument is highlighted by Chris Busby in his book *Wings of Death*:

> Finally, despite considerable evidence of low-level radiation effects from man-made pollutants, including cancer clusters near nuclear installations such as Sellafield, there has never been a plausible theory of how such effects can be produced at levels below those we are exposed to from Natural Background Radiation. This is the rock on which the nuclear castle is built: no progress in the crucial debate can be made without addressing the problem that cancer rates in populations exposed to widely different background radiation levels do not differ significantly.

In previous sections of this chapter, various aspects of this highly important issue have been addressed. We have noted that likening the effects of Natural Background Radiation, which contributes one hit per year to the nucleus of each cell in the body, to man-made hot particles, which can be responsible for repetitive hits to the nuclei of a small volume of cells, is a false analogy. We have further explored how man-made radioactive pollutants differ from Natural Background Radiation in their ability to exploit vulnerabilities in biological systems. Busby's Second Event theory and the Petkau Effect are examples of how low doses of certain types of internal emitters can cause harm to cells in ways that NBR cannot. What remains to be addressed are the epidemiological studies themselves. What evidence has led proponents of nuclear pollution to the conclusion that the risk of cancer is the same for people living in areas with different levels of Natural Background Radiation?

The ECRR cites 10 major epidemiological studies that have shaped current understanding of the consequences to health from living in areas of high NBR. Contrary to the claims of the Cult of Nuclearists, seven of these studies demonstrated increased incidence of chromosome defects in the study population. The remaining three studies didn't investigate this type of aberration. In addition, five of the studies revealed elevated rates of cancer. A study in Japan revealed increases in stomach and liver cancer. Of two studies in Iowa, one uncovered a 24% increase in bone cancer and the other demonstrated a 68% increase in lung cancer. A study in Brittany revealed a 132% increase in stomach cancer. Finally, a study from Scotland testified to a 60% higher rate of leukemia. Despite this evidence of increased cancer risk in areas of high Natural Background Radiation, the ECRR is cautious in interpreting the results.

> For a number of reasons, it is uncertain how the results of these studies can inform discussion about risk from radiation exposure. First, for many of these studies, the populations suffer stresses associated with living in the Third World where cancer is not a major cause of death owing to earlier competing causes and the generally shorter lifespan.

> In addition, population natural selection for radiation resistance over a long period may be expected to confound any attempt to find a suitable control group: thus the repair efficiency for cancer-inducing lesions in genes would be expected higher in the exposed populations than the controls. In addition, the considerable amount of evidence which shows that different populations have different genetic susceptibility to cancer of different sites makes it impossible to draw any universally applicable conclusions from background radiation studies.

The ECRR expresses skepticism that definitive conclusions can be reached on the effects of low-dose radiation from the comparison of people living in areas of high and low Natural Background Radiation. The reasons for this are as follows:

1. Disadvantaged populations occupy many of the areas of high NBR. Competing causes of death may claim lives prior to the advent of radiation-induced cancer. This would have the effect of lowering the cancer rate in a population and making high levels of NBR appear less hazardous.

2. Accurate health data is not available in many areas of high NBR. Thus, the true rates of cancer in the population are not ascertainable.

3. Valid epidemiological studies are hampered by an inability to find genetically comparable populations to serve as suitable control groups.

4. Over generations, increased radiation resistance will have been bred into members of a population exposed to high NBR due to natural selection. Consequently, cancer rates in these areas would be lower.

5. Global fallout from weapon testing must be factored into any consideration of the health effects of Natural Background Radiation. Different geographical locations have been contaminated by different levels of fallout. This complicates any attempt to discern the part played by NBR on cancer rates.

6. Due to the low levels of radiation being studied and the low cancer rates predicted for these dosages, the determination of cancer rates due to NBR relative to other possible causes is highly unlikely.

In the southern Indian state of Kerala, a population of several thousand people resides on a strip of land 10 km by 1 km that has some of the highest levels of natural

radioactivity of any place on Earth. This heightened radioactivity is caused by an abundance in the soil of the mineral monazite, which contains 10% thorium phosphate. As a consequence, the population receives an exposure to NBR that is two times the world average. In the article *Can ICRP Be Trusted to Set Radiation Exposure Standards?*, Rosalie Bertell (1995) speaks about Kerala and offers some important insights that challenge the nuclear industry's claim that high levels of NBR are not hazardous to health:

> Recently the BEIR Reports have used atomic bomb data to support their theory that humans have undetectable genetic damage from the atomic bombs. As early as 1957, the World Health Organization called together a Committee to study the genetic effects of radiation and to recommend protection of the human gene pool. In the publication by this committee, Kerala, India, was identified as the best place to study the genetic effects of chronic radiation exposure over several generations. To date, the nuclear establishment has not undertaken a serious study of this population, indicating their lack of concern for genetic damage. In one study, undertaken for another purpose, the authors noted that the exposed population of Kerala had an abnormally high rate of Down's Syndrome. Researchers also found significantly high levels of broken chromosomes in the exposed group. In 1988, with the help of Indian researchers, I agreed to act as scientific advisor to a study of the people of Kerala. Researchers found that they were the first group to interview and examine the population, although the nuclear industry often uses Kerala as its example to "prove" that low-level radiation is harmless.
>
> We now have measurements of the background radiation at grid points all through the contaminated area, detailed information on about 32,000 exposed households and matched control households not living on contaminated sand, and information on 92,000 pregnancies. Our preliminary findings are that the rate of Down's Syndrome is 3 to 4 times higher in families living on the radioactive sand than for control families. Other problems which were more than doubled for the radiation-exposed group were congenital blindness and deafness, epilepsy, malformation of long bones, childlessness (couples who wanted to have children but could not), and various kinds and degrees of mental retardation. In the communities living on the contaminated soil, every one of the so-called sentinel mutations, rare genetic damage, was found. This was not true for the matched controls.

There are radiobiologists who do not believe in the necessity of a threshold dose for

the onset of radiation injury and who recognize Natural Background Radiation as the source for a small percentage of the cancers suffered by the global population. From their point of view, the random hits from NBR occasionally spawn a cancer that escapes immune system surveillance. The inescapable conclusion is that some small number of cancers are the inevitable price paid by humanity for simply dwelling on planet Earth. From this perspective, any additional radiation liberated into the environment increases background levels and contributes to an increase in the cancer rate. Recent evidence for this concern was presented in the magazine *New Scientist* in an article entitled "Background Radiation Enough to Trigger Cancer". The article reviewed research conducted by Keith Baverstock of the World Health Organization's European Center for Environment and Health, in Bonn, and Paivi Kurttio of the Radiation and Nuclear Safety Authority, in Helsinki. Investigating the incidence of papillary thyroid cancer among the children of Europe as a result of the accident at Chernobyl and from medical x-rays, the researchers determined that the nine milligrays of natural radiation absorbed by the average child's thyroid during the first nine years of life would cause one or two cancers per million children each year. This predicted rate matches the incidence of the disease of children under the age of 15 in Finland, Norway, Sweden and Denmark. This study followed an earlier one conducted by Mark Little, a medical statistician at Imperial College in London. Using data from the A-bomb survivors, Little calculated that between six and sixteen percent of the cases of papillary thyroid cancer were caused by Natural Background Radiation. The cause(s) of the remaining cases was never determined.

Plenty of studies have been done that implicate exposure to background levels of radiation with increased incidence of cancer. Those who claim no such evidence exist are liars. In the article, "Inconsistencies and Open Questions Regarding Low-Dose Health Effects of Ionizing Radiation", Nussbaum and Kohnlein provide the following information:

> A Birmingham team of scientists was able to correlate the very large database on the geographical distribution of childhood cancers in Great Britain of the OSCC [Oxford Survey of Childhood Cancer] with accurate measurements of terrestrial gamma-ray dose rates over a 100 km grid covering England, Scotland and Wales (Knox *et al.*). The terrestrial doses for that area vary by up to a factor of five, between about 15 nGy/hr and 80 nGy/hr (0.013-0.070 cGy annually). This study suggests that "background radiation might be an element of the causal chain of the majority of childhood cancers" (Knox *et al.*). It is noteworthy that a simple regression analysis of childhood cancers found a negative correlation with dose, in qualitative agreement with the above-mentioned studies with inadequate controls for confounding factors that continue to be cited in support of radiation

> hormesis. When confounding socioeconomic factors, identified as being strongly correlated with childhood cancer mortality, were included in the OSCC analysis, the association with background dose turned significantly positive.
>
> Consistent with the British OSCC results, a recent US study also found a significant association between childhood cancer incidence and a variation in annual external background gamma-ray dose rate by nearly a factor of two (0.05-0.092 cGy per year) over an area within a radius of approximately 10 miles from the Three Mile Island nuclear plant. On the basis of risk factors derived from the A-bomb survivor study, no detectable trend in cancer among children should have been found from variations in background exposures of such small magnitude. This study, however, found a 50% increase in risk of cancer for children under 15 years with every 0.01 cGy increase in estimated annual background gamma-ray dose (Hatch and Susser). As in the British background study above, the high sensitivity to radiation is most likely related to exposures during the earliest fetal stages of development.

SCAM NUMBER THIRTY-FOUR: Compromise your position as a respected scientific organization and voice of authority to advance a veiled political agenda and skew the debate over the risks to health of low-dose exposure.

Health physicists are experts in the field of occupational and environmental radiation safety. Over and above any other group of professionals, they should provide unbiased, objective information to the public on the effects to health from radiation exposure. If political intrigue compromises their impartiality, the layman is set adrift without a compass, unable to evaluate in the midst of a radiation emergency what information is trustworthy and potentially lifesaving. The Health Physics Society, the organization that represents the profession, thus did a disservice to the field of health physics and to the public when, in January 1996, its Scientific and Public Issues committee published a position paper entitled "Radiation Risk in Perspective". The paper addressed the risk to health from exposure to radiation below five to 10 rem. Their position was reaffirmed in 2001 and underwent minor alterations in 2004. The paper is remarkable for the way it exploits uncertainty in matters of science and produces an authoritative, decisive, unconditional position bearing momentous political benefits for the nuclear industry. This was not lost on members of the profession. In the Society's newsletter of May 1996, one member pointed out that the position sounded "more political than scientific" and another wrote in predicting that the statement would "harm the credibility of the [Society] as a radiation protection organization" (Fairlie and Resnikoff).

The argument set forth in the position paper starts out with a debunking of the Linear No-Threshold Hypothesis. It reiterates the familiar refrain, that current radiation protection standards and practices have come to rely on the premises of the LNTH only because "insurmountable intrinsic and methodological difficulties exist for determining if the health effects that are demonstrated at high radiation doses are also present at low doses." The argument then goes on to assert that evidence exists that this model is an over-simplification, that it is not applicable for a number of specific cancers, and that heritable genetic damage has yet to be observed in human studies. Further, the role played in the induction of cancers and genetic mutations by such biological mechanisms as DNA repair, bystander effect, and adaptive response "are not well understood and are not accounted for by the linear, no-threshold model."

Having established the unreliability of the LNTH, the paper then mentions the limitations of the current knowledge base:

> Radiogenic health effects (primarily cancer) have been demonstrated in humans through epidemiological studies only at doses exceeding 5–10 rem delivered at high dose rates. Below this dose, estimation of adverse health effect remains speculative.
>
> Epidemiological studies have not demonstrated adverse health effects in individuals exposed to small doses (less than 10 rem) delivered in a period of many years.
>
> Below 5-10 rem (which includes occupational and environmental exposures), risks of health effects are either too small to be observed or are nonexistent.

The political punch line is then delivered as if it is the only reasonable deduction to be made from the above observations:

> In view of the above, the Society has concluded that estimates of risk should be limited to individuals receiving a dose of 5 rem in one year or a lifetime dose of 10 rem in addition to natural background. In making risk estimates, specific organ doses and age-adjusted and gender-adjusted organ risk factors should be used. Below these doses, risk estimates should not be used. Expressions of risk should only be qualitative, that is, a range based on the uncertainties in estimating risk

> (NCRP 1997) **emphasizing the inability to detect any increased health detriment (that is, zero health effects is a probable outcome)** [emphasis added].

The policy paper concludes by stating the implications of its position on the assessment of risk as it pertains to radiation protection:

> (a) The possibility that health effects might occur at small doses should not be entirely discounted. The Health Physics Society also recognizes the practical advantages of the linear, no-threshold hypothesis to the practice of radiation protection. Nonetheless, risk assessment at low doses should focus on establishing a range of health outcomes in the dose range of interest and acknowledge the possibility of zero health effects. **These assessments can be used to inform decision-making with respect to cleanup of sites contaminated with radioactive material, disposition of slightly radioactive material, transport of radioactive material, etc.** [emphasis added].
>
> (b) Dose (the sum of individual doses in a defined exposed population expressed as person-rem) has been a useful index for quantifying dose in large populations and in comparing the magnitude of exposures from different radiation sources. However, collective dose may aggregate information excessively, for example, a large dose to a small number of people is not equivalent to a small dose to many people, even if the collective doses are the same. Thus, for populations in which almost all individuals are estimated to receive a lifetime dose of less than 10 rem above background, collective dose is a highly speculative and uncertain measure of risk and should not be used for the purpose of estimating population health risks.

For the uninitiated, the following interpretation is provided: The Health Physics Society decrees that science has yet to produce unequivocal epidemiological evidence on the effects to health of low-dose exposure. It will ignore the fact that this is perhaps symptomatic of the limits of epidemiology or of the way epidemiology has so far been applied to studying the problem. Further, the Society will ignore the fact that evidence of low-dose effects has not been produced because science currently lacks other means besides epidemiological ones for measuring the biological consequences to populations from releases of radiation into the environment. Rather, we are going to declare that low-dose effects are unobservable, which we take to mean inconsequential or nonexistent. Consequently, consistency demands that we abandon all models that provide a quantitative estimate of what

might be happening to the health of populations from low-dose exposure. The profession of health physics advocates that it is illegitimate to posit that because "x" amount of radiation is released amidst a population, that "y" amount of health detriment will result within the dose limits mentioned. Estimating the likelihood of an individual developing cancer or the number of cancers expected throughout the population is an invalid and fruitless exercise. Policy makers need only be advised of the range of possible health outcomes in the dose range of interest. What can this possibly mean other than zero health effects? (Recalling Exhibit B and the dubious mainstream practice of averaging energy over masses of tissue, the reader might notice how the official party line is reaffirmed by the Health Physics Society, that risk estimates are only *bona fide* if they are based on organ doses. This position effectively discredits all epidemiological studies, as exemplified by the studies of Gould and Goldman, that demonstrate a cancer risk from low-dose exposure but which do not have available organ dose estimates. This is a very tricky and sophisticated ruse, repeatedly pulled out and dusted off to prevent useful types of information from gaining "scientific" credibility. This point will be elucidated further in the next chapter, *The Chicanery of the US Radiation Accident Registry*.)

The political motivations of those who crafted the Health Physics Society policy statement are all too transparent. They manifest their political bias by ignoring convincing evidence that demonstrate health detriment following low-dose exposure. By fiat, the Health Physics Society has usurped the scientific method. It has decreed that uncertainty in low-dose effects warrants the abandonment of all tools that enable us to come to terms with the possible public health impact of our deeds. Risk factors for low-dose exposure are invalid. Risk estimates are impermissible. Population effects are not to be predicted. Such conclusions free us from constraint and give us permission to fly blind. In one fell swoop, the Health Physics Society has decreed that we need not fret over how many people are being sickened by depleted uranium weaponry, that many sites contaminated by radioactivity need not be cleaned up, that caution may be abandoned in the disposal of low-level radioactive waste. Emissions from nuclear installations and commercial nuclear power plants are without hazard. We can resume nuclear testing without concern. These are outdated issues. Decision-makers can be freed of such petty concerns because we haven't figured out how to measure the effects and a possibility exists that there aren't any at all. The regulatory handcuffs can be taken off the nuclear industry. And think of the money we'll save. Dismissing the Linear No-Threshold Hypothesis gives absolution to the Cult of Nuclearists.

Although his critics will abhor it, the words of John Gofman will prove to be the conscience of this whole nasty business:

> **It is true, of course, that radiation-induced cancers in a population from very low doses will rarely if ever be detectable epidemiologically, because of the signal-to-noise ratio. But it does not follow (from the lack of direct observation) that the cancers are therefore unreal, hypothetical, speculative, theoretical, nonexistent, or imaginary. No rational person will deny that one of the most commonplace (and important) functions of science is to let people know what is really happening when direct observation is impossible** [emphasis added] (Gofman, 1990).

SCAM NUMBER THIRTY-FIVE: When promoting the benefits of nuclear technology to the layman, rely on half-truths and incomplete information to disguise costs to the environment which ultimately become risks to health.

The Cult of Nuclearists is dedicated to fulfilling its vision of the centralized control of electricity production through nuclear power. Having botched this plan the first time around with poor reactor design, exorbitant cost overruns, harrowing accidents and the massive loss of public support, they have been patiently waiting in the wings for an opportune moment to resume their campaign. Recent concerns over global warming and greenhouse gas emissions from coal-burning power plants have served as a pretext for touting nuclear fission as a promising "green" energy source. Since former vice-president Al Gore began stumping for an international commitment to combat global warming, a nuclear renaissance has blossomed. Orders for new nuclear power plants are in the works in numerous countries throughout the world. Admittedly, commercial nuclear reactors do not discharge greenhouse gases into the atmosphere. And it's just possible that next-generation reactor design may indeed guarantee the impossibility of catastrophic core meltdown. Nonetheless, nuclear power will never be green or clean.

When nuclear power is hyped as the solution to global warming, many important facts go quietly unmentioned. For starters, worldwide production of electricity releases only nine percent of the annual emissions of human-generated greenhouse gases. Although a nine-percent reduction would be significant, this goal could not be achieved even if all the coal-burning facilities in the world were shut down and replaced by nuclear ones. The reason for this is that uranium mining, milling, conversion, enrichment and separation; reactor-fuel fabrication; the building and decommissioning of nuclear power plants, and the storage of radioactive waste all require huge amounts of energy which is generated by the burning of fossil fuels. Thus, contrary to nuclear industry propaganda, nuclear power is responsible for emitting large quantities of greenhouse gases. Dr. Helen Caldicott has cited examples of this atmospheric pollution in her article "Nuclear Power Is The Problem, Not

A Solution':

> In the US, where much of the world's uranium is enriched, including Australia's, the enrichment facility at Paducah, Kentucky, requires the electrical output of two 1,000-megawatt coal-fired plants, which emit large quantities of carbon dioxide, the gas responsible for 50 per cent of global warming.
>
> Also, this enrichment facility and another at Portsmouth, Ohio, release from leaky pipes 93 per cent of the chlorofluorocarbon gas emitted yearly in the US. The production and release of CFC gas is now banned internationally by the Montreal Protocol because it is the main culprit responsible for stratospheric ozone depletion. But CFC is also a global warmer, 10,000 to 20,000 times more potent than carbon dioxide (Caldicott).

Any short-term benefit to be derived from nuclear power in reducing CO_2 emissions will quickly disappear as high-quality uranium ore reserves become depleted. This is made clear in the treatise "Can Nuclear Power Provide Energy For The Future; Would It Solve the CO_2-Emission Problem?":

> If the known uranium resources were used to exhaustion the total electrical energy produced would only amount to the present-day worldwide electrical energy use in three years.
>
> If all of the contributions are taken into account [i.e., burning of fossil fuels throughout the uranium fuel cycle], a nuclear plant causes the emission of about one-third of the CO_2 produced by a gas-burning plant. But this relatively favorable ratio only holds as long as there are rich uranium ores available. When these are exhausted, the use of leaner ores will lead to the production of more CO_2 by the operation of a nuclear plant than by a gas-burning plant. In the long run, nuclear power is therefore not a solution to the CO_2 emission problem.
>
> The reason for this little-recognized problem of nuclear energy is that it costs energy from other sources (principally produced by burning fossil fuels) to produce nuclear energy. More disturbing is that many of these energy costs will have to be paid generations after a nuclear power station has stopped producing electricity. These are thus energy debts: debts incurred during its production lifetime, which our yet unborn descendants will have to pay (van Leeuwen and Smith).

In the process of generating electricity for immediate consumption, commercial nuclear power plants produce massive quantities of radioactive waste that will remain hazardous for millennia. The energy debt borne by the future will be paid by the greenhouse gas emissions produced to handle this radioactive waste. Currently, there are more than 80,000 tonnes of high-level radioactive waste stored on site at the nation's 103 nuclear power plants, in either indoor wet pools or outdoor dry casks. An additional 33 tonnes are produced annually at a typical 1000-megawatt facility. Fossil fuel consumption will eventually be required to transport this dangerous dross to permanent waste repositories. According to current plans proposed by the Department of Energy, tens of thousands of shipments by truck, train, and barge will be required to transport irradiated nuclear fuel and high-level radioactive waste through 45 states and the District of Columbia to the sequestration facility being readied at Yucca Mountain in Nevada. The construction of this facility required the burning of fossil fuels. Future facilities will likewise result in greenhouse gas emissions. The long-term maintenance and monitoring of these facilities, for the incomprehensible tens of millennia that will be required, will also require ongoing fuel consumption. A third source of the energy debt bequeathed to the future that will be paid by fossil-fuel emissions is the energy expended to dismantle each nuclear facility at the end of its life-cycle. During the course of a reactor's operation, the reactor vessel, piping and valves, and construction materials making up the containment building will have been made radioactive through neutron activation. This huge mass of radioactive debris will require disassembly, removal and burial — once again, all provided by fossil fuels.

Moreover, due to its high lethality, radioactive waste presents an attractive target to terrorists. Since 9/11, the once remote possibility of an attack on a nuclear facility has become more real. Any accident or terrorist attack resulting in a breach of containment of the reactor vessel, an interruption in core cooling, or the liberation of stored radioactive waste would produce an unimaginable catastrophe. Using Chernobyl as the template, what can be imagined is an environmental catastrophe, an epidemic of radiation-induced diseases, the forced relocation of large segments of the population, major economic disruption and so forth. Regardless of how clean the technology is, even one such event would negate any derived benefit of boiling water by nuclear fission to generate steam.

Shortsighted human beings fail to learn lessons from history. Wars break out. Social disruption engulfs whole societies. Economies collapse. In the event of these remote but not unimaginable misfortunes, the radioactive waste scattered around the country may be neglected or abandoned. Interruption in the guarding of this nuclear detritus or its proper cooling and storage may lead to environmental releases that would create uninhabitable zones for hundreds of human generations. Anyone unwittingly entering one of these areas in the remote future will be vulnerable to radiation-induced disease and death. This is a

possible legacy of the "clean" technology being ballyhooed today.

When nuclear power is promoted as a clean technology, scant mention is made of the biologically significant quantities of radionuclides routinely liberated into the environment at each reactor site. Gaseous effluents contain fission-created or neutron-activated noble gases, iodine-131, particulates, and tritium. Liquid effluents include fission/activation products, dissolved and entrained gases, and tritium (Harris and Miller). This radioactivity is not credited with producing illness in the population despite numerous cases of cancer clusters in the proximity of nuclear installations. The operators of commercial nuclear power plants repeatedly assure the public that they operate within the safety guidelines issued by the federal government and that their emissions are strictly regulated. But how do members of the public really know what is being dumped into the environment from nuclear installations? The following will illustrate that radioactive pollution contaminates the environment to a greater extent than is admitted, that doses to the population are consequently higher than acknowledged and that the risks and incidence of radiation-induced cancer are greater than anyone cares to admit.

Beginning in 1990, citizens independent of the nuclear industry established the C-10 Radiological Monitoring Network in proximity to the Seabrook Nuclear Power Plant in New Hampshire. Within the 10-Mile Emergency Planning Zone in southern New Hampshire and northeastern Massachusetts, 25 monitoring stations were set up, mounted on the homes of volunteers. Each station included a beta/gamma detector, a gamma-only detector and a weather station. These instruments continually fed data into a computer for later retrieval. The data was periodically collected and analyzed in the Network's Newburyport office. Early on the morning of November 29, 1995, three stations southwest of Seabrook registered the passage of a radioactive cloud. The beta/gamma detector readings jumped as high as eight times normal background levels and remained there for several hours. The gamma-only detectors recorded levels 15 times normal background. The weather stations measured wind blowing steadily from the northeast, strongly suggesting the source of the cloud was Seabrook Station. According to a report of the incident:

> We occasionally register elevated readings (though never before as high as those on November 29) at one or more C-10/RMN stations, and follow up by checking with plant spokespeople or the Nuclear Regulatory Commission's (NRC's) on-site inspector. Usually we have an answer in 2 or 3 days, and it often turns out that the high readings coincide with various "evolutions" within the reactor complex. This time our inquiries went unanswered for weeks. Only after we announced that we were going to the press did Seabrook's spokespeople get back to us.

> Their story was that the plant had indeed been venting radioactive material at the time of our high readings. They claimed that the material was tritium — a form of heavy hydrogen — which had been vented at rates so low that our sensors should not have picked it up. Furthermore, they acknowledged that the plant's Wide Range Gas Monitor had been inoperative since about 30 minutes before the venting began, and that "periodic sampling" of the outflow was performed as a back-up.
>
> There were two problems with this. The first was with the specific radioisotope involved. Tritium does not emit gamma photons, but the highest C-10/RMN sensor response was from our gamma-only detectors, indicating that the cloud could not have consisted of tritium alone. The second problem was with the rate at which Seabrook admitted venting. We have our own computer model for simulating the dispersion of radioactive clouds. It's based on the same mathematics and references as the models used by the nuclear industry and the NRC, and was developed with the assistance of several scientists. Using this computer model, which accounts for factors of weather and plant construction, we found that the rate at which Seabrook admitted venting could not have caused a cloud of the magnitude we observed. Instead, we found that a release rate about 50,000 times greater than Seabrook admitted was required to reproduce our cloud (S. Miller 1996).

In response to the press conference that eventually took place, the Citizens' Radiological Monitoring Network came under heavy fire. Lobbyists for Seabrook worked to have state funding of the organization rescinded. Public relations personnel tried to discredit the Network in the press, attacking their data and instrumentation and offering a number of alternative explanations for the high radiation readings. What was the truth? As in many other such confrontations, the issue was wrestled into ambiguity so that potential outrage was smothered and the public's concerns pacified. This gambit is another scam in its own right, a proven method of quelling opposition and of disarming a wary citizenry.

Before moving on, it is important to mention the benefits bestowed on the commercial nuclear industry from inaccurate models of risk. Nuclear power plants are licensed to release radioisotopes into the environment based on current models of radiation effects and the assumption that the permitted levels will not create illness in the population. Because risk factors have been inaccurately assessed, nuclear facilities have been given latitude to legally discharge hazardous levels of radioisotopes, while simultaneously covering up the

price paid in the eroded health of unsuspecting citizens. Here is a case in point provided by Rosalie Bertell:

> If it is decided that fatal cancer incidence rate should be the biological endpoint on which the regulations are based, and I do not accept this as the best indicators of problems, then the radiation industry needs to conform to the same standards of injury as is used for regulating the chemical industry.
>
> The State of Minnesota, in the USA, decided that a nuclear waste dump should not be able to cause more than one cancer (fatal of non-fatal) over the lifetime (70 years) of an exposed person. This is the standard which the State used for chemical polluters. Based on this, a criteria of no exposure of the public above 0.0005 mSv per year was derived by the State Department of Health. This Standard is being enforced in that State, although it is ten thousand times lower than the current permissible dose to the public per year under US Federal Law, namely 5 mSv per year.
>
> In Ontario, the Advisory Committee on Environmental Standards (ACES) expressed astonishment that the nuclear industry was permitting itself to pollute the drinking water with up to 40,000 Bq of tritium per liter, under the 5 mSv per year federal radiation dose limit for members of the public. When the ICRP reduced the recommendation to 1 mSv per year, the industry agreed to lower the permissible level of tritium in water to 7,000 Bq per liter. When the ACES used the industry risk estimates for calculating the expected number of fatal cancers considered to be "permissible" under this Standard, they called for an immediate reduction in permissible levels to 100 Bq per liter, with a further reduction to 20 Bq per liter within five years. This was based of the standard setting used for toxic chemicals. This means the radiation protection guide line allows 350 times more fatal cancers than chemical standards would allow.
>
> While I understand mathematically why the nuclear industry, dealing with a mixture of radionuclides sets such unreasonably high permissible values, I see also that these high values are used for public relations reasons to assure the trusting public when there is a spill or abnormal incident at a reactor. Stating that the exposure was less than 10% of the permissible dose, sounds reassuring! Yet if one knew that the permissible dose was 350 times too high based on cancer deaths caused, 10% would be seen as 35 times too high. It is in the

> interest of the nuclear industry, hiding behind ICRP, to carry on the subterfuge that "permissible" implies "no harm" (Bertell, February 1998).

SCAM NUMBER THIRTY-SIX: Violate people's innate process of evaluating and assuming risk in their daily lives by imposing highly risky technology upon them and then falsely underrate the risks that accompany that technology.

In 1953, President Eisenhower initiated the Atoms for Peace Program. A major unstated goal of this initiative was to assuage the terror that had settled into the hearts of a large segment of the population as a result of the development of nuclear weapons. These monstrosities did tremendous violence to people's sense of personal security and trust in the uninterrupted continuity of life. The possibility of instantaneous demise by forces beyond one's control was routinely on peoples' minds. Images of brutal victimization were deeply disturbing to the psychological equilibrium of many. Responding to this unease, the government crafted a propaganda campaign to transform the menacing atom into the beneficent atom. This well-orchestrated crusade was intended to pave the way for the public's embrace of nuclear power. However, despite the best efforts of government PR, the majority of the population remained wary of the new technology. In people's minds, nuclear power was incestuously intertwined with nuclear weapons, and the possibility of radiation-induced disease, regardless of how remote, was terrifying. This mindset, an obstacle to the plans of the empowered, became an area of academic interest and was studied by experts in the field of risk analysis.

According to the website of Argonne National Laboratory, risk analysis can be defined as follows:

> The systematic study of uncertainties and potential harm that may be encountered in such areas as the environment, business, engineering, and public policy. Risk denotes a potential negative impact to an asset or some characteristic of value that may arise from some process or future event. Risk analysis seeks to (1) identify the probability of loss, or risk, faced by an institution or business unit; (2) understand how and when risks arise; and (3) estimate the impact of adverse outcomes. Once evaluated, risks can be managed by implementing actions to mitigate or control them.

Basically, risk analysis is a study of systems. After defining the successful operation of a system, efforts are made to identify the factors that might disrupt the operation of the system, the consequences of this disruption and ways to minimize the likelihood that such

disruptions might occur. An adjunct to this study, one relevant to the nascent nuclear industry, was the study of the likelihood of events that would lead to the release of radiation into the environment and what risks such releases might pose to the health of the surrounding population. When the infinitesimally small projections of risk predicted by the nuclear industry failed to quell opposition to nuclear power, social psychologists began investigating risk assessment: how do human beings evaluate risks in their daily lives, and how do they prioritize which risks they are more or less willing to expose themselves to in exchange for the benefits derived?

This field of inquiry delivered novel insights into human behavior. It revealed that all modern human beings share similar criteria for evaluating potential hazards. These patterns of thought act as filters that color people's perception as to what risks are acceptable or unacceptable. The table below summarizes these perception factors.

Risk Perception

Acceptable	**Unacceptable**
Voluntary	Involuntary
Individual Control	Others Control
Clear Benefits	Unclear Benefits
Trustworthy Sources	Untrustworthy Sources
Ethically Neutral	Ethically Objectionable
Natural	Artificial
Familiar	Exotic
No Historical Associations	Memorable Associations
Less Dread	High Dread
Visible	Undetectable
Immediate Effect	Delayed Effect
Known, Understood	Uncertainty, Variability
Little Media Attention	High Media Attention

To illustrate the utility of this material, a simple example will suffice. If asked, a majority of people will say that they feel a lot safer driving their car than flying in an airplane. They cling to this belief even after being apprised of the fact that driving is statistically much more hazardous than flying, and the likelihood of being in a fatal accident on

the highway greatly exceeds that of being in one while airborne. That people feel safer in the more dangerous situation is not so enigmatic when the thinking behind such an assessment is understood. People know that driving a car is a risky venture. But while driving, they feel in control of their vehicle and are in a familiar situation. They are on terra firma rather than up above the clouds. This not only produces less dread, but it seems to offer more options in the event that the situation turns unpredictable. Further, car accidents are rather humdrum whereas fiery air crashes make front page news. And bumping into another car and being forced off the road is, on reflection, less fear-inducing than being trapped in a terrifying descent that will surely lead to a fiery crash that burns hundreds of bodies beyond recognition.

The vehement opposition to nuclear power is no mystery once the mechanisms of risk perception are understood. Nuclear power has been imposed on populations throughout the world without recourse to referenda. Due to the complex nature of the technology, others are in control of it, and this increases feelings of vulnerability. The benefits are unclear, given that other methods of generating electricity are available, and the safe disposal of radioactive waste is an unsolvable dilemma. Originating from government and big business, and with a long history of cover-ups, nuclear power is perceived as coming from an untrustworthy source. Being intertwined with the production of nuclear and radiological weapons, the technology is perceived as ethically objectionable. Being extremely high-tech, it is viewed as artificial and exotic. It has memorable associations with Three Mile Island and Chernobyl. The idea of a catastrophic nuclear accident instills extreme dread. Released radiation is undetectable and health effects from exposure are delayed, uncertain, and variable. And reportage in the media of accidents, shutdowns, protests, cost overruns and so forth has furthered people's suspicions of the technology. In a nutshell, the majority of people, due to their inborn psychological processes that come into play when assessing risks, perceive nuclear power as hazardous and unacceptable.

The nuclear industry found itself behind the eight ball as the process of risk assessment began to be delineated. In response, they devised a brilliant gambit to woo public opinion and make nuclear power appear less risky. The PR strategy they adopted went something like this: *The study of risk perception provides concrete evidence that people can be irrational when assessing risks in their daily lives. When assessing alternatives, they give themselves over to emotion and make choices based on fear that are not in their best interest. When a number of people do this simultaneously, they develop unwise social policy that is not for the common good. To prove this, let's apply statistical analysis to the host of risks people confront daily. When we do this, we discover that nuclear power is less risky than a whole host of risks that people voluntarily assume without hesitation.*

This appeal to rationality over what is painted as spontaneous, unreflective prejudice

is a highly seductive argument. And it was supported with a number of interesting, and sometimes humorous, observations. For instance, Mettler and Moseley in their book *Medical Effects of Ionizing Radiation* provide information on how various conditions are statistically associated with lifespan shortening. For instance, a male who remains unmarried can expect for his life to be shortened, on average, by 3,500 days. A male cigarette smoker will lose approximately 2,250 days from his life. Being 30 percent overweight will reduce lifespan by 1,300 days. Having cancer robs its victims, on average, of 980 days, and a stroke diminishes life span by 700 days. Compared with these life-shortening factors, radiation appears downright innocuous. Natural background radiation, according to BEIR 1972, shortens life by eight days, medical x-rays by six days, and reactor accidents between 0.02 and 2.0 days.

Following a different track, *Medical Effects of Ionizing Radiation* reports the risks confronted in daily life that increase the chance of death by one chance in a million. Data from this line of reasoning is presented in the table on the following page.

This data is intended by the nuclear establishment to awaken people to their inherent foolishness, which by implication is the basis for their resistance to nuclear power. The peanut butter eaters and the bicycle riders are silly to object to nuclear power. In the course of their daily lives, they choose activities that carry similar or greater risks than those posed by nuclear power. The routine pleasures of life put people in jeopardy. If they saw clearly, they could not possibly find fault with nuclear power.

This line of reasoning leads to a disturbing conclusion: basically, people are dummies. They don't understand themselves, and they don't understand the world they live in. They must be rescued from their follies by science and rationality. An elite body of enlightened policy makers must arise to lead humanity out of ignorance to a new golden age. This perspective is typified in an article that appeared in the *Washington Post*, entitled "Let's Get Real About Risk." It was written by David Ropeik, director of risk communication at the Harvard Center for Risk Analysis. Although not mentioning nuclear power directly, it could easily be used in its defense. The author begins by illustrating how much human effort is misdirected:

> Hundreds of thousands of Americans will die this year, deaths that can be prevented. Millions will get sick with preventable illnesses. Billions of dollars and countless hours of human effort will be wasted unnecessarily — all because we are afraid of the wrong things.
>
> In a frenzy of fear we are pouring millions this summer into protecting ourselves from the West Nile virus, and spending only a fraction of

Activity	***Cause of Death***
Smoking 1 cigarette	*Cancer, heart disease*
Drinking 1/2 liter of wine	*Cirrhosis of the liver*
Living 2 days in New York or Boston	*Air pollution*
Rock climbing for 1 1/2 minutes	*Accident*
Traveling 6 minutes in a canoe	*Accident*
Traveling 10 miles by bicycle	*Accident*
Traveling 30-60 miles by car	*Accident*
Flying 1000 miles by jet	*Accident*
Flying 6000 miles by jet	*Cancer caused by cosmic radiation*
Living 2 months in Denver	*Cancer caused by cosmic radiation*
Being a man age 60 for 20 minutes	*Illness*
Eating 40 tsp of peanut butter	*Liver cancer caused by alfatoxin B*
Eating 100 charcoal-broiled steaks	*Cancer from benzopyrene*
Living 5 years at site boundary of a typical nuclear power plant in the open	*Cancer caused by radiation*
Living 150 years within 20 miles of a nuclear power plant	*Cancer caused by radiation*
Risk of accident by living within 5 miles of a nuclear reactor for 50 years	*Cancer caused by radiation*

that sum on public education encouraging people to wash their hands, which would eliminate far more disease transmission than killing every mosquito in America.

Public and private spending on the cleanup of hazardous waste in America is estimated at $30 billion a year. Hazardous waste is a real problem, but the number of people whose health is at risk because of it is actually quite low. Compare that $30 billion with only $500 million

> a year on programs to reduce smoking, one of the leading preventable causes of death in America.

After illustrating the folly in current decision-making, the cause of this folly is diagnosed: fear.

> We could make decisions that are more rational and informed. In many areas, science can identify the physical hazards, tell us how many people are likely to be affected by each one, what various mitigations will cost and how effective we can expect them to be. We can rank risks and remedies and put things in perspective. But we don't. Instead, we make policy based more on fear than fact.
>
> Let's be blunt. This irrational response kills people. In a world of finite resources, we can only protect ourselves from so many things. If we overspend on risks such as pesticides or asbestos, which are real but of relatively low magnitude, we have less to spend on greater threats such as bacterial food poisoning or fossil fuel emissions. As a result, thousands of the people exposed to those higher risks will die.
>
> The usual suspects blamed for bad policy are politics, greed, the media, even the open, manipulatable nature of democracy itself. True, these are all factors in a process that often becomes a battle between competing private agendas rather than an informed search for policies that will serve the greatest common good. But the principal underlying cause of wasteful choices that seek protection from the wrong bogeymen is fear.

Ropeik then identifies how irrational fear, when embraced by large groups of people, can lead to adoption of irrational public policy:

> But society, with limited resources, must be more rational than that. When individual fears become group fears, and when those groups, organized or not, become big enough or visible enough to put pressure on the government to provide protection from less dangerous threats, we can end up with policies that leave a lot of people in the way of harm from higher risks that we're doing less about.

For the greater good, the solution to this dilemma is deference to the wisdom of a body of independent experts for the rational assessment of societal risks. Ropeik proposes the creation of a nongovernmental agency to "provide us with credible, trustworthy guidance on risks." His Risk Analysis Institute would rank hazards according to their likelihood

and consequences, and oversee cost-benefit analysis to outline possible solutions and maximize resources to protect the greatest number of people. To assure the objectivity of the institute in promoting rational policymaking, the utopian ideal is presented that funding would have no strings attached, and that the "scientific work would have to be carried out by professionals who are chosen for their education and training, their expertise and reputations for integrity, neutrality and open-mindedness, not for who their political friends are."

Without question, there is tremendous merit in the idea of injecting rationality and objectivity into the process of risk assessment in order to create effective social policies. However, in the hands of an empowered clique such as the Cult of Nuclearists, risk analysis has been transformed, yet again, into a mesmerizing display of smoke and mirrors. As such, it has become a tool to confound the better judgment of people and do violence to their deep-seated impulse to arrange their lives for the maximum degree of safety, security, and tranquility. The attempt to manipulate the perception of the risks posed by nuclear power is readily understood within the context of how this technology initially evolved. Nuclear weapons were imposed on society by government without any form of democratic debate. As the implications of Hiroshima and Nagasaki burrowed deeply into the collective consciousness, people responded appropriately to these weapons from their inborn processes of risk assessment, and by all criteria, judged them to be unacceptable. However, they lacked the political strength to demand limits to the technology or the foresight to realize that, left to its own devices, the Cult of Nuclearists would assemble before everyone's eyes the arsenal of Armageddon. For a large sector of humanity, the normal process of managing risk was forever upset. They were victimized and traumatized by this reconfiguration of their familiar landscape. Impotent to change this external menace, people's psychology was forced to undergo modification. They had to integrate into their lives increased feelings of dread and insecurity, fear for the future welfare of their children, anxiety about the precarious fragility of all that made life worth living. People had for the first time in history to face the horrible possibility that the continuity of life into the future might be irrevocably interrupted. When nuclear power appeared on the landscape, these same feelings became associated with the threat of the accidental release of radiation. By the way people normally go about assessing risk, this attitude was not unjustified.

The crux of the problem of nuclear weapons and nuclear reactors is that the Cult of Nuclearists has always prized these technologies above the psychological well-being of the people of the Earth. They introduced a technology that by all measures was inappropriate to human happiness and safety and remained unmoved by the average person's response to this technology, i.e., that it was unacceptably risky. Rather than respect this instinctive judgment and work to create a new world order more friendly to the inhabitants

of the Earth, the Cult of Nuclearists advanced its own agenda. To this end, they fabricated elaborate deceptions to beguile people's natural inclinations. This was the motivating impulse for much of the lying and deceit revealed within these pages. When the process of human risk perception began to be clarified, proponents of nuclear weapons and reactors manufactured a strategic response for the purpose of demonstrating how misguided human beings can be when relying upon their native instincts for assessing risk. A new social-psychological paradigm was promoted, centered upon the idea that humans are essentially irrational when assessing certain types of risk. To save them from their folly and guide them to seeing the world in its "true" light, social scientists needed to present the risks of daily life in the cold logic of statistical analysis. By this method, humanity could be freed from its "irrational" fears, limited funds could be apportioned more wisely for addressing "real" hazards, more lives could be saved and the greatest good could be achieved for the greatest number.

At the risk of offending the reader, there is no word in the English language that comes close to characterizing this line of reasoning other than "mind-fuck." It is a cheap trick designed to belittle and invalidate humanity's collective perception of the nuclear hazard. Rather than admit to the inappropriateness of their technology, inappropriate to the pervasive human desire for safety, security, and a sense of well-being, the Cult of Nuclearists is attempting to beguile humans into accepting that they, the people themselves, are inappropriate to the technology. According to their argument, human nature as it applies to risk assessment is imprisoning the species in fear and shortsightedness, thus holding society back from progress. People are repelled by nuclear technology only because they don't see the world aright. The cure for this pervasive nuclear phobia is reeducation by the enlightened perspective of "objectivity." Once this is accomplished, people will awaken to the realization that nuclear power presents no greater risk to their welfare than a short trip in a canoe or a brief ride on a bicycle.

This argument is hogwash. It is based on the fallacy that the perspective of the social scientist and that of the risk-taker are freely interchangeable. Social scientists use statistical analysis as one window on life in their attempt to discern patterns in human behavior. They objectify life in order to study it. They abstract from all the nuances that are involved in individuals formulating preferences of one course of action over another in order to draw certain generalizations about population dynamics. The perspective of the risk-taker, the one who is at risk, is entirely different. For this person, the assessment of risk is a multifaceted process which takes into account past history, knowledge of the world, expectations, preferences, aspirations, intuitions, physical sensations, appetites, emotions, desires, and so forth. If making choices were an entirely rational process and if knowledge of statistics were sufficient to alter behavior, no one would smoke, no one would be over-

weight and everyone would wear a seat belt. Obviously, this is not the case.

For the moment, let's assume that the foregoing statistics are accurate, even though they are based on the lies uncovered in this book, and that there is no difference in the risk to life-shortening between eating 40 teaspoons of peanut butter and living for five years at the perimeter of a nuclear power plant. Knowledge of this fact is not sufficient to change most people's attitude or behavior. Peanut-butter eaters will continue to eat peanut butter with abandon and real estate values around nuclear power plants will remain in a slump. Why? Because personal risk assessment involves more than simply selecting the objectively safest alternative. It involves the very subjective process of creating within oneself a sense of security and safety. All of us are gamblers in the casino of life. We are constantly exposed to a vast matrix of risks, any one of which could ruin or end our lives. To manage this, we push many risks out of our awareness. Others that are more within our control, we may choose to address so as to reduce the hazard they *may* produce in our life. We choose to better our odds of avoiding certain types of catastrophe by electing to wear seat belts, stop smoking, or go on a diet. However, these efforts offer no complete assurance that we will not die in a car accident, contract lung cancer, or suffer a heart attack. Constant vulnerability to chance and the unexpected is the reality of life. The psychological cushion to this state of precariousness is the sense of security derived from one's personal process of risk assessment and management regardless of how accurate it may be objectively.

If statistical knowledge of relative risk lacks the power to supplant most people's inborn processes of risk assessment, what alternative remains for those intent on creating social policy at odds with the public's perceptions? The only option is to circumvent these perceptions by ignoring and overriding them. This is the ultimate purpose of the proposed Risk Analysis Institute. "Experts" are to be enlisted to apply their "superior" wisdom and purported "objectivity" to contravene what is characterized as the passions and ignorance of the masses. Sidestepping the annoying pitfalls of having to deal with public opinion, these experts will work directly with policy makers and lawmakers to create a society reflecting their own values and interests. Undisguised, this is social engineering of a new world order by an elite class not accountable to the people who will have to live under the social policies imposed upon them without consensus. The Risk Analysis Institute is a utopian ideal fraught with peril for humanity. This is most clearly illustrated by a living embodiment of such an organization, the ICRP. To all external appearances, this body of experts provides lawmakers throughout the world with objective information on radiation risk. But as we have revealed, behind their facade of purported objectivity, this organization is a servant of the Cult of Nuclearists, bolstering and legitimizing its misdeeds while ruining the health of untold numbers of victims.

The safety of commercial nuclear power plants is a subject besmeared with obfuscation. Consequently, a legitimate avenue of investigation is to question how the statistics of relative risk listed above were derived. If they are based on the "presumed" dosages to the population from the "assumed" levels of radioactive effluents routinely vented into the environment, and if the risk factors of the ICRP are then applied to these dosages, it should be apparent by this point in the discourse that the hazard to health will be greatly understated. As we shall explore in the following chapter, if the statistics of risk are based on the casualty data recorded in the US Radiation Accident Registry, the conclusions reached as to the hazards of nuclear power plants will be nothing less than a mockery to intelligence. Not everyone in the population is equally at risk from discharges of radioactive pollutants from nuclear installations. If the total amount of radiation released into the environment is treated as if it were distributed to the entire population, the presumed risk is vastly underrated. It would be more accurate to examine the risk incurred by those individuals living immediately downwind of nuclear power plants. As will be revealed in Exhibit F, this type of investigation will reveal elevated risks of breast cancer to people living downwind compared to those living upwind of these facilities. Inclusion of this data in comparisons of relative risks would forever tarnish the myth of the harmlessness of nuclear power.

Statistics can be easily manipulated to create this or that false impression. For instance, statistical analysis may be used to demonstrate the low risk of life-shortening posed by nuclear weapons, the improbability of another Chernobyl-type accident, or the minuscule hazard posed by the planet's accumulated radioactive waste. But such fine number-crunching would be brought to naught by the single improbable occurrence of a nuclear war that decimated 90 percent of the population of the Earth. The safety record of commercial nuclear reactors can be touted *ad infinitum*, but the low-probability event of a simultaneous breach of containment and loss of coolant to a reactor core would contaminate the entire population of a large metropolis. Stored nuclear waste has yet to cause catastrophic loss of life, but the safety record of today may fail to account for hazards facing an unsuspecting humanity thousands of years in the future. Mathematical probabilities may predict that nuclear accidents are far-fetched and unlikely, but far-fetched and unlikely things happen all the time. The question is not how improbable the risk, but whether or not we can afford to have such a risk in our midst at all. Is the technology worth the risk of the mass casualties that seem so implausible? Rather than go to the statistical tables for answers, we should travel to Belarus and ask people there if another Chernobyl is worth the risk. We should travel to Hiroshima and ask the survivors what they think of America's defense policy. We should ask sick veterans returning from Iraq whether they think the ICRP's risk factors for inhaled uranium are accurate.

Contrary to the beliefs of the pundits within the Cult of Nuclearists, the people of

the Earth are not dummies. We recognize the lies for what they are. We are acutely aware that we are living on the brink of nuclear catastrophe. We have witnessed calamitous radiation accidents, and there is nothing that can convince us that these will not happen yet again. Where before we used to protect our children from discovering about the birds and bees, today the horrific secret to be kept from tender ears is that their lives can be incinerated in a microsecond by some deluded idiot. We long to live in a world where we can ride bikes and go canoeing and eat peanut butter sandwiches without being burdened by the thought of having our world ruined by radioactive contamination. We recognize that the Cult of Nuclearists and their policies are an embedded cancer in the body politic. Excising them from our midst may be treacherous because such an operation may kill the host as well. But the people do not have unlimited patience with threat, injustice and deception. Let us hope that Cult of Nuclearists will quantify that risk as well.

SCAM NUMBER THIRTY-SEVEN: Block the dissemination of all information that raises questions as to the validity of the current estimates of risk from internal contamination by radionuclides.

Governments and the nuclear industry derive a tremendous boon from the flawed model of radiation effects as it applies to low-level internal contamination. It gives them license to contaminate populations with radionuclides and escape accountability for their deeds. Their minions, availing themselves of the types of scams elucidated within these pages, can demonstrate within the wake of even the most catastrophic releases that dosages to the exposed populations fall within the safety guidelines set by the radiation protection agencies, and thus, that the resulting risks to public health are relatively insignificant. To maintain this facade, the Cult of Nuclearists is heavily invested in creating the impression that the science of radiation effects is more advanced than it in fact is, and that a worldwide consensus exists in the understanding of how radiation affects human health. To give the impression that current models are impeccable, extreme pressure is brought to bear on dissidents who refuse to toe the line and who, in defiance of the status quo, voice unorthodox viewpoints. Routinely, these whistleblowers are marginalized and their work discredited. Among the tactics used to silence those promoting dissenting points of view: threats and intimidation, loss of employment, demotion, salary cuts, funding cuts, refusal of employers to allow publication of research, rejection of publication by the scientific journals and so forth. A common rationale for such retribution is that conclusions in defiance of current models are illegitimate because they fall outside the mainstream of accepted scientific thought. What escapes due consideration is the possibility that the mainstream itself is hopelessly polluted and in need of cleanup.

Given this tyrannical suppression of independent thought, it is not surprising that

experts in the radiation sciences have been silenced when attempting to warn the world of the hazards of depleted uranium. A recent example came to light in February 2004, with the publication of an article in the UK's *Sunday Herald* which reported that the World Health Organization had kept secret a report warning that Iraq's civilian population faced a long-term threat of increasing rates of cancer from inhaling DU dust from weapons fired by British and US forces. Dr. Keith Baverstock, who had been employed by WHO for 11 years as a senior advisor on radiation and health, authored the 2001 study in collaboration with Professor Carmel Mothersill of Canada's McMaster University and Dr. Mike Thorne, a radiation consultant. Baverstock told the *Sunday Herald*: "Our study suggests that the widespread use of depleted uranium weapons in Iraq could pose a unique health hazard to the civilian population. There is increasing scientific evidence that the radioactivity and the chemical toxicity of DU could cause more damage to human cells than is assumed." As reported by the newspaper which had attained a copy of the research:

> Baverstock's study pointed out that Iraq's arid climate meant that tiny particles of DU were likely to be blown around and inhaled by civilians for years to come. It warned that, when inside the body, their radiation and toxicity could trigger the growth of malignant tumors. The study suggested that the low-level radiation from DU could harm cells adjacent to those that are directly irradiated, a phenomenon known as "the bystander effect." This undermines the stability of the body's genetic system, and is thought by many scientists to be linked to cancers and possibly other illnesses (Edwards 2004).

Baverstock offered the following observation:

> I believe our study was censored and suppressed by the WHO because they didn't like its conclusions. Previous experience suggests that WHO officials were bowing to pressure from the IAEA, whose remit is to promote nuclear power. That is more than unfortunate, as publishing the study would have helped forewarn the authorities of the risks of using DU weapons in Iraq.

The WHO was quick to dismiss these allegations as totally unfounded. "The IAEA role was very minor," said Dr Mike Repacholi, the WHO coordinator of radiation and environmental health in Geneva. "The article was not approved for publication because parts of it did not reflect accurately what a WHO-convened group of international experts considered the best science in the area of depleted uranium," he added.

As an aside, the *Sunday Herald* article concluded by offering observations by Pekka

Haavisto, chairman of the UN Environment Program's Post-Conflict Assessment Unit in Geneva:

> Haavisto's greatest worry is when buildings hit by DU shells have been repaired and reoccupied without having been properly cleaned up. Photographic evidence suggests that this is exactly what has happened to the Ministry of Planning building in Baghdad.
>
> He also highlighted evidence that DU from weapons had been collected and recycled as scrap in Iraq. "It could end up in a fork or a knife," he warned.
>
> "It is ridiculous to leave the material lying around and not to clear it up where adults are working and children are playing. If DU is not taken care of, instead of decreasing the risk you are increasing it. It is absolutely wrong."

The suppression of the Baverstock study is not an isolated phenomenon. Investigating the medical effects of depleted uranium can lead to termination of employment. After 19 years of service to the US government, Dr. Asaf Durakovic, Chief of Nuclear Medicine at the Veterans Administration hospital in Wilmington, Delaware, was fired after undertaking investigations into the medical effects of depleted uranium on sickened veterans from the first Gulf War. Although he had served in the Gulf himself, Durakovic was unaware until he returned to the US that depleted uranium munitions had been deployed in the Gulf. Says Durakovic:

> I only discovered indirectly in September 1991 that depleted uranium had been used on the battlefield. I was horrified. When scientists conduct experiments using this material, we dress like astronauts. Our soldiers had no protection. And this attack could have potentially exposed the entire population of the Gulf region. Soil samples from Iraq show radiation levels more than 17 times the acceptable level (Arbuthnot).

Dr. Durakovic's story of the obstacles he encountered while attempting to treat contaminated veterans is interesting and well worth repeating. It is a textbook case of the types of intrigue that can be waged against honest scientific investigation.

> In 1991, 24 soldiers from the 144th Transportation and Supply Co., New Jersey, were referred to me by Ventnor Clinic in my capacity of

Chief of Nuclear Medicine, VA Medical Facility, Wilmington, DE. All of the veterans were referred to me for the opinion and diagnostic assessment of their DU body burden. My expertise is in the internal contamination of radioisotopes and I was the only published researcher in the federal VA system with research on transuranic elements at the time these soldiers were referred to me. Although I personally served in Operation Desert Shield as Unit Commander, my expertise of internal contamination was never used because we were never informed of the intended use of DU prior to or during the war.

The research on the effects of transuranic elements in the human system is not well known as prior accidents have dealt with many isotopes (Chernobyl) and the Persian Gulf War deals with one actinide, i.e., uranium.

From January 1991 until August 1991, these soldiers were on a tour of active duty in Saudi Arabia and after the ground war started were located at the KKMC, King Khalid Military Camp, where it was their duty to unload battle-damaged M1A1 tanks, Bradleys, and M113 tanks destroyed by DU armor-piercing shells from friendly fire of helicopters, airplanes, and other tanks.

The soldiers worked on these tanks. During this time, soldiers had constant contact with these vehicles. Those that were required to receive the vehicles actually lived very near them, ate lunch on top of them, and cooled themselves inside of them. They had been told not to let anyone photograph or take souvenirs from them so they kept the tanks close at hand.

On March 10, 1991, a Battle Damage Assessment Team dressed in full radioprotective clothing arrived, stating that they were from Washington to assess the radioactivity of specific tanks. They reviewed the tanks for four days, fully dressed in the 90 degree temperatures.

At the conclusion of the assessment, the soldier in charge of the crew required to move the equipment, was told that the tanks were "hot," to mark them with the atomic symbol and not to let people go near them. The Assessment Team had detected .26 to 1.0 rad inside the tanks. [With an RBE (Relative Biological Effectiveness) factor of 10, the dose rate is 2.6 to 10.0 rem/year for the surrounding body tissue.

In the US, the Code of Federal Regulations regarding energy specifies an annual limit of 0.17 rem/year and a specific limit of 0.5 rem/year for an individual in the general population.]

After that evaluation, the soldiers were told to cover the tanks with tarps and not to photograph them. The Team stated that the tanks were not dangerous to those required to work in their environment. One soldier was given an outdated dosimeter which began to detect radiation right away despite the fact that it was long past its expiration date.

My diagnostic strategy consisted of their referral to the VAMC [Veterans Administration Medical Center] of Boston to the internationally known expert on low energy detection of internal contamination, Dr. Belton Burroughs who with Dr. David Slingerland performed whole body count of uranium-238 on several of the referred veterans. It was found by a rather insensitive and outdated whole body count that 14 of the 24 patients referred contained decay products of radioactive uranium. On the basis of this, more sensitive equipment, specifically a Germanim crystal, was applied for the project which was then terminated. All work that was conducted on behalf of DU contamination was coordinated through the Persian Gulf Registry of the Wilmington VA hospital. All records were subsequently lost.

The urine samples of these same patients were sent to the US Army Radiochemistry Lab in Aberdeen, Maryland. Again, some samples never reached the lab and the results of those that did were supposedly lost.

According to my experimental research on lab animals and extensive review of the literature, uranium can hardly be detected by the external methods including whole body counting and urine analysis. Therefore I recommended that the veterans should be sent to the SANDIA National Labs in Albuquerque, NM which specializes in the pulmonary pathways of contamination with transuranic elements.

Furthermore, an objective analysis in the main site of uranium incorporation which is the skeletal system, should be performed by an autoradiographic analysis of the skeletal deposition of uranium by the bone necropsy specimens.

> Neither of the above recommendations were followed because no one took the veterans' illnesses seriously. Two of the 14 soldiers have died since returning from the Persian Gulf. A recommendation for autopsy which should have included autoradiographic analysis of the skeletal deposition of uranium, was ignored.
>
> The 144th Transportation and Supply Company has since been scattered all around the United States, making it impossible for unified testing and analysis.
>
> Due to the current proliferation of DU weaponry, the battlefields of the future will be unlike any battlefields in history. Since the effects of contamination by uranium cannot be directed or contained, uranium's chemical and radiological toxicity will create environments that are hostile not only to the health of enemy forces but of one's own forces as well.
>
> When released, DU aerosol particles are carried on the winds, their range as fallout virtually unlimited and as they migrate they contaminate air, soil, and water. So released, it is available for uptake by humans via inhalation, ingestion, or absorption. In such a toxic environment, fighting personnel will find themselves victims of their own weapons as well as those of the enemy. Due to the delayed health effects from internal contamination of uranium, injury and death will not always be immediate to the battle, but will remain lingering threats to "survivors" of the battle for years and decades into the future. The battle field will remain a killing zone long after the cessation of hostilities. Environmental contamination will linger for centuries posing an ongoing health threat to the civilians who reclaim the land and subsequent generations (Durakovic, Statement).

In one interview, Durakovic offered an opinion as to way the US government was actively engaged in hiding the effects of depleted uranium:

> Was there a reason officials didn't want information on DU victims of the Gulf War to become public? According to Dr Durakovic there are two main reasons - and they both involve money. By the year 2000 the bill to clean up waste uranium from the US nuclear industry would have amounted to more than $200 billion. So a lot of cash could be saved if the uranium was recycled in the arms industry. And of course there is the issue of compensation. The US Government would have to pay out billions if it could be conclusively proven that

> DU-coated weapons were causing illness in returned American troops (Arbuthnot).

In February 1997, Dr. Durakovic, on behalf of Gulf War veterans, wrote a letter to President Clinton asking for an inquiry into DU contamination. Two months later, he was fired. In an interview on the radio show *Democracy Now*, Durakovic spoke of his termination:

> I was fired in the year 1997. Because after the Persian Gulf War I, I was approached by the officials of the different departments of the US government who asked me to stop my work on the depleted uranium, which I obviously could not agree with, because I was mandated by the government of the US to take care of my patients, and I was the head of Nuclear Medicine Department of the V.A. Hospital in Wilmington, Delaware. So when I discovered a high percentage of contamination with the DU in Gulf War I veterans, every effort was made to stop my work. Which I obviously couldn't. I'm a medical doctor, and my responsibility is for the well-being of my patients. So, in 1997, I was fired (Broadcast Exclusive).

Dr. Durakovic has offered a sobering thought in regard to the misapplication of uranium for military purposes:

> Uranium is dangerous, it does cause cancer, uranium does cause mutation, and uranium does kill. If we continue with the irresponsible contamination of the biosphere, and denial of the fact that human life is endangered by the deadly isotope uranium, then we are doing disservice to ourselves, disservice to the truth, disservice to God and to all generations who follow (Catalinotto).

The Cult of Nuclearists will use any means to silence its critics of the currently accepted model of radiation effects. Free minds and unbiased intellectual inquiry are its most potent enemies, and it is these that must be silenced. Its raging intolerance was recently in evidence on a seemingly inconsequential battlefield, the meeting table of CERRIE, the Committee Examining Radiation Risk from Internal Emitters. In 2001, Michael Meacher, then Environment Minister in the UK, established CERRIE. Due to the controversial nature of its subject matter, CERRIE was structured along novel lines for a panel offering scientific advice to policymakers. Members of the committee were selected from three different camps. Some came from the National Radiation Protection Board and British Nuclear Fuels, a government-owned company which produces nuclear fuel, runs reactors, generates and sells electricity and reprocesses spent reactor fuel. Other members

of the committee represented the Green movement or were people whose scientific views challenged those of the NRPB. The remainder were supposedly neutral academics. The mandate of the committee was to undertake a review of the health risks posed by internal emitters and produce a final report which adequately presented the views of all parties. Topics for which a consensus was reached were to be identified. For subjects on which differences of opinion were irreconcilable, the reasons for the disagreements were to be elucidated in accessible language and suggestions were to be made for avenues of future research which might help resolve the conflicting points of view. All committee members were to agree to the final report, acknowledging that it faithfully included the full breadth of the committee's deliberations and that it accurately presented all opposing arguments.

Typifying the titanic struggle between those who endorse technologies that liberate ionizing radiation into the environment and those who oppose them, CERRIE failed to fulfill the directive with which it was charged of producing a document agreed upon by all of its members. The working coalition split along ideological lines, and the final report exhibited obvious bias in favor of the reigning orthodoxy. In flagrant violation of the reason for which it was created, CERRIE authored a paper that failed to present a full and fair presentation of all points of view. Disagreements among committee members were in many cases mentioned only in passing, and no space was allotted to adequately explain to the reader the underlying reasons for the differences in scientific opinion. On the important subject of post-Chernobyl infant leukemia, the final report did an excellent job of whitewashing the evidence of major errors in the risk factors published by the ICRP. Those who felt their points of view were not accurately reflected in the document published a separate minority report which contains the information suppressed by the majority.

The CERRIE debacle is mentioned here for only one reason. As the committee's deliberations drew to a close, representatives of the Cult of Nuclearists interjected a novel method of intimidation into the proceedings with the intent of controlling the final report and stifling free and open discussion that the current model of radiation effects is flawed. At the committee's last meeting, the Chairman produced a letter written by lawyers within the Department of Environment Food and Rural Affairs (DEFRA). The letter warned that if the final report contained any libels or "negligent misstatements on factual matters," liability could potentially fall on everyone connected with the report: the committee members, the government departments, the printers and the distributors. In a blatant threat to the livelihood of each member of the committee, the letter indicated that each member individually would be liable for damages if the government were sued by anyone on the basis of these unspecified negligent misstatements. As to why the committee failed to produce a unified report, the probable explanation was revealed in a *Sunday Times* article by Mark

Gould and Jonathan Leake entitled "Government Gags Experts Over Nuclear Plant Risks." According to this article, the 12 members of CERRIE each received a letter warning them that they could be sued for defamation if they included within their final documents the contents of what eventually became the minority report. This harassment produced the desired results. The "official" CERRIE document gives no indication that serious questions exist as to the accuracy of the current model of radiation effects. Successfully marginalized, the separately published minority report will undoubtedly receive little exposure.

The tactics used by elements within the British government to subvert CERRIE provides strong evidence that a new Inquisition is evolving to persecute heretics who preach against the state-sponsored doctrine. Anyone proposing ideas at variance with what is promoted as true by those in power may be brought to trial for libel and fined or imprisoned. This tolls the death knell for unbiased scientific inquiry — a cornerstone of Western civilization for the last four hundred years. To declare and support with evidence that the Hiroshima Life Span Study is flawed science, or that the ICRP publishes inaccurate risk factors, or that Sellafield is inducing leukemia in children will no longer be tolerated as a valid alternate interpretation of what is going on in the world. These pronouncements will instead be judged as "negligent misstatements on factual matters" and their authors will be criminalized.

SCAM NUMBER THIRTY-EIGHT: Design epidemiological studies in such a way as to guarantee that the results will underestimate the risk to health from radiation in the environment.

What knowledge exists about the medical effects of radiation on populations has been garnered from epidemiological studies. This research also has been used to validate the models of radiation effects upheld by the radiation protection agencies. Since nuclear/radiological weapons, commercial nuclear power and the biological impact of low-level radiation are such highly politicized subjects, it is not surprising that epidemiological studies are sometimes structured and implemented, either by intention or accident, to reflect the prejudices of the researchers conducting them. Biased studies pollute the knowledge base and are a propaganda device. Of interest here are the distortions of fact that can be insinuated into population studies in order to "prove" the correctness of ICRP models and thereby "verify" the minimal hazard predicted by the risk factors.

The ECRR has identified a number of common errors that have appeared in published epidemiological studies of radiation risk:

1. *Wrong Doses*: Many of the dosage scams mentioned previously have become

incorporated into studies of contaminated populations. When dosages are assessed inaccurately, no meaningful conclusions can be drawn about risks. In most studies of contaminated populations, dosages are not actually measured in each member of the study group but estimated or, in the vernacular of radiation epidemiologists, "reconstructed". This practice, based on numerous assumptions about the migration of radionuclides through the environment, is a simple means by which radiation studies can be subtly manipulated to deliver predetermined or politically acceptable results.

A common tactic used by the AEC during the period of aboveground weapon testing was to formulate dosages to the population from fallout in terms of external radiation. Conveniently, this served to downplay the level of exposure to those people living downwind by ignoring the additional dosages caused by internal emitters. This error of ignoring the cumulative effects of all the radioisotopes involved has compromised the Hiroshima Life Span Study, studies of populations living downwind of nuclear weapon detonations and studies of Chernobyl. As a variation on this theme, population studies are invariably based on the currently accepted models of external radiation. In instances where internal emitters are taken into account, the contribution made from external radiation and internal radiation are usually combined to derive a single dose estimate which is treated *as if* it were completely delivered externally. If internal emitters pose an enhanced hazard, as this book argues it does, no reliable conclusions about the hazard posed by radionuclides in the environment can be produced by this methodology.

2. *Wrong Controls*: To study radiation effects, the incidence of illness in an exposed population must be compared to that of a similar population that did not receive the exposure. If an inappropriate control group is selected for study, the health risks from radiation can be rendered woefully inaccurate. One way where this can occur is when the population chosen as the control group has been likewise exposed to radiation. When this occurs, the radiation-induced cancer rate in the study population will be made to appear lower than it actually is, perhaps even "nonsignificant," due to the heightened incidence of radiation-induced cancer in the control group. This error is a central shortcoming of the Hiroshima Life Span study, where members of the control group received undetermined dosages from internal emitters. It has also crept into studies of the inhabitants of the Marshall Islands, of people living downwind of the Nevada Test Site and of populations contaminated by the fallout from Chernobyl.

It is important to note that the entire human population has been exposed, both internally and externally, to radiation from weapon-test fallout, accidents, and routine ventings from nuclear installations. There *is* no uncontaminated subpopulation that can serve as a control group to test the impact of this pollution on the health of the human species.

Internal contamination by novel fission products befouling the environment may be more hazardous than Natural Background Radiation but its effect is masked by this universal contamination. The presence of these radionuclides in the environment might well explain the rise in the incidence of cancer across the population since the middle of the twentieth century. This lack of a suitable control group has important implications for interpreting of epidemiological studies of radiation and cancer causation. When the incidence of cancer in a study group exposed to the effluent of a radiation accident is compared to that of members of the general population, the frequency of radiation-induced cancer will end up appearing less than it in fact is, and the risk of cancer from radiation will be underestimated.

The ECRR notes that it may be inappropriate to select members of the general population as a control group if the study group does not itself reflect the general population. One example is the "war survivor effect" prejudicing the Life Span Study. Those in Hiroshima who survived a long war, the atomic bombing and the hardships that followed this holocaust became members of the study group in a project designed to determine radiation effects in humans. However, the survivors of this horrific ordeal might not have been representative of either the Japanese population or of the entire human race. The hardships of living through the war followed by the extreme trauma of the bombing, and survival through the subsequent five years before the onset of the study may have preferentially selected individuals with stronger immune systems or genetic resistance to certain types of radiation effects. As a consequence, their incidence of cancer may have been atypically low compared to members of the population at large. Similarly, employees in the nuclear industry may manifest a "healthy worker effect" which lowers their rates of cancer in comparison with equivalent age groups within the general population. Fit, employable individuals undergoing regular medical exams who selected themselves to work in the nuclear industry and were then selected again for employment may not represent a true cross-section of the general population. Such comparisons may generate spurious results about the risks to health from radiation exposure.

3. *Wrong Sample*: It is not uncommon for groups that have been differentially exposed to radiation to be pooled together in a common study group. For instance, people living within a defined radius of a nuclear installation may be grouped together in an effort to detect the effect of living near the facility on rates of cancer. This method can mask the fact, for instance, that those people living downwind of the plant will have received higher doses than those living upwind. When the number of cancers recorded is compared to the size of the population under investigation, those living upwind will dilute the findings, lowering the cancer rate and lowering the apparent risk.

4. *Wrong Assumptions*: This entire chapter has been devoted to proving that the current model of radiation effects is biased toward underestimating the risk to health from exposure to radiation. The assumption built into this model can profoundly influence the interpretation of data collected in epidemiological research. The ECRR provides a clear example. In studies of nuclear workers and the effects of Chernobyl in Europe, "the assumption of a linear no-threshold dose response has resulted in many clear observations of effect being discounted because high-dose groups may have lower cancer rates than intermediate-dose groups." According to the LNT hypothesis, those in a population who received the highest dosages should manifest the greatest degree of radiation-induced illness. If the greatest number of casualties do not exist in the high-dose group, then radiation is discounted as the cause of any detected cancer increase across the population. This line of reasoning is based on models originally designed to understand the effects of external radiation. It may not be valid for low-level internal exposure. For instance, a study might reveal that the greatest incidence of birth defects or childhood leukemia occurred in the intermediate-dose group rather than the high dose group. Does this finding justify the conclusion that radiation was not the cause? Certainly not! Perhaps a greater number of fetuses were spontaneously aborted in the group suffering the greater exposure, thus lowering the incidence of disease in the children of members of this cohort. The expectation of observing a linear dose response can thus blind researchers into discovering that low-level internal exposure may carry with it an enhanced risk for radiation injury. In line with this observation is another which deserves mentioning. When speaking of the effects of Chernobyl on the rates of cancer in Europe, the ECRR makes the following point:

> In addition, epidemiological studies have been influenced by or countered with the predictions of the ICRP risk models for populations exposed to the doses resulting from the discharges. These predict very modest effects which would generally be difficult to establish against the large background cancer rates experienced by the study populations and therefore, when increases in cancer are seen in such populations they are ignored or at least not ascribed to exposures from Chernobyl.

Another incorrect assumption mentioned by the ECRR has been incorporated in studies of the rates of cancer in geographical areas of high Natural Background Radiation. To "prove" the harmlessness of low-level radiation, studies have been conducted comparing cancer rates between populations living amidst different levels of naturally occurring radiation. When the areas of high NBR are not found to demonstrate higher rates of cancer, the conclusion jumped to is that low-level radiation is not a hazard to health. One factor that is not taken into account is the selection over time of radiation resistance among

members of a population exposed for generations to the elevated radiation in the environment. As noted by the ECRR: "Inducible radiation resistance has been demonstrated in animal studies yet no allowance has been made for this when comparing populations in Natural Background studies."

As a third example, the ECRR notes that current models of radiation effects are based on the assumption that cancer is initiated directly from a single exposure event which induces genetic alterations. The genetic theory of cancer on which this is based fails to take into account other factors that may come into play in influencing the progression of a cancer. For instance, immune system stress, diet, or other environmental toxins may either aggravate or mitigate the effects of the initial aberration thereby affecting radiation-induced cancer rates within populations.

5. *Wrong Conclusions*: The ECRR notes that it is quite common for the conclusions drawn in an epidemiological study to be out of sync with the data collected during the course of the study. Journal abstracts or the conclusions appearing at the end of research papers claiming no observed effect between radiation exposure and cancer incidence have been observed to contradict the information included in tables or text within the body of the papers.

For a long and detailed examination of the types of errors that have corrupted important studies that purport to show that radiation exposure has little or no effect on public health, the reader is advised to consult chapter five, "Paradigm Deconstructed," in *Wings of Death*.

SCAM NUMBER THIRTY-NINE: Use the risk factors to structure the perception of the health consequences of a radiation release.

In Edgar Allan Poe's short story, *The Masque of the Red Death*, all the influential people of a country assemble for a masquerade ball in the castle of a nobleman. Outside, a plague is ravaging the less fortunate population. Secure in their presumption that they are immune to the tribulations taking place beyond their walls, all are horrified to discover when they remove their masks, that Death has been an uninvited guest within their midst throughout the entire gathering. This, their final realization, marks the moment of their demise.

For purposes of this discussion, we must ask what costume, today, is Death wearing?

Death is disguised by the risk factors published by the radiation protection agencies. We fail to recognize Death in our midst because it is so craftily concealed.

Before this discussion proceeds, a single point needs to be hammered home. When estimates are manufactured for the number of people injured by nuclear weapon testing, how are the figures computed? On the basis of the risk factors! When a radiation accident takes place, what is used to determine the likelihood of illness to those dwelling downwind? The risk factors! Before commercial nuclear power plants are licensed, what criteria are used to determine the amount of radionuclides that can be legally discharged and the likely health effects of these to the surrounding population? The risk factors! For people employed in the nuclear industry, how is potential hazard to their health estimated? The risk factors! When modeling different accident scenarios at radioactive waste repositories, how is health detriment of those potentially exposed determined? The risk factors! When computing the possible hazards of a breach of containment accident during transport of radioactive materials along highways or railroad lines, how are possible casualty figures derived? The risk factors! On what basis is the hazard to health estimated from incorporating low-level waste into consumer products? The risk factors! When cancer patients receive radiation therapy, how are their chances for another cancer being induced by their therapeutic dose of radiation calculated? The risk factors! How are hazards to our own troops or enemy civilians evaluated when designing and deploying uranium weapons? The risk factors! When estimating collateral injury to the surrounding population from the proposed deployment of nuclear bunker-buster bombs, what information is necessary for such calculations? The risk factors! How are the number of radiation deaths produced in the varying scenarios of nuclear war fighting during World War III determined? The risk factors! The risk factors legitimize the entire nuclear enterprise. Human beings tolerate technologies that cause radiation exposure solely on the basis of their belief that this exposure represents minimal risk.

Scam Number Thirty-Nine is the preeminent scam, the reason for being of all the other scams. It lies at the heart of all the mischief that has infiltrated and corrupted the science of radiation protection. By the elaborate swindle deconstructed within these pages, the Cult of Nuclearists has fabricated inaccurate risk factors and then used these inventions to veil its misdeeds before the public. To fully appreciate the insidious role played by the risk factors in blinding humanity to true radiation effects across populations, one must get a feel for the profound indeterminacy that accompanies a radiation release. Due to the nature of the phenomenon, the impact of vented radioactivity on public health is clouded in ambiguity. Once liberated, radioactive atoms invisibly migrate through the environment at the whim of ever-changing meteorological and geophysical forces. From their point of origin to their ultimate abode, no one knows their fate. Extensive environmental monitor-

ing can provide a map of patterns of dispersal and potential avenues for contamination of the food chain, but this in itself will not divulge who was contaminated and to what extent. Those contaminated will never know they have absorbed radiation that may undermine their health. The most meticulous scrutiny will never disclose the fate of each radioactive atom as it courses through their bodies. When an atom undergoes radioactive decay, no one will witness the molecular consequences of the event or the possible genetic damage inflicted on a cell. When a cancer develops decades later, the victim will never realize that he or she was a casualty of a radiation accident.

With the exception of incidents that produce acute radiation syndrome, radiation injury in the wake of a radiation release is delayed and invisible. Only years or decades after an exposure event do indications of injury begin appearing, if anyone is bothering to look for them, in the form of an increased incidence of naturally occurring diseases. In the aftermath of a Chernobyl-type accident, perhaps the first indications of harm to a population are a growth in the number of miscarriages, stillbirths and birth defects. Increased rates of leukemia among children who were in the womb during or immediately after the event may begin appearing during childhood or adolescence. Among those who were children at the time of the accident, the dietary absorption of radioiodines will increase the number of thyroid abnormalities and thyroid cancers diagnosed within a few years of exposure. The next disease that may be identifiable as radiation-induced is leukemia throughout the population, with rates *beginning* to climb perhaps as soon as five years after the event, and continuing to climb as the population ages. Increases in the frequency of other types of cancer may go unnoticed for decades due to their long latency periods.

The conundrum facing the epidemiologist is how to determine the rates of those illnesses in the population which are radiation-induced against the pool of identical illnesses that occur naturally or from other environmental toxins. Due to normal statistical fluctuations in the frequency of these diseases over time, trends are not easily identifiable, or if they are, may require the passage of decades for meaningful elucidation. In some instances, what further complicates assessing the health consequences of a radiation accident is the sparsity of accurate data. Particularly in underdeveloped countries, illnesses may be misdiagnosed, causes of death may not be properly identified or may go unrecorded, and statistics on morbidity and mortality may not be gathered or may remain incomplete. Not to be overlooked is the politically motivated corruption of accurate data sampling. As noted in Scam Number Twenty-One, cancer registries are susceptible to fraud, or as in the case of Ukraine after Chernobyl, Soviet authorities forbade doctors from including leukemia in their diagnoses. Finally, definitive and indisputable conclusions of radiation effects on populations are a rarity among epidemiological studies. Due to political clashes between pro-nuclear and anti-nuclear factions, studies angering one camp are routinely challenged and

refuted by researchers of the opposing camp. Controversies inevitably erupt in the wake of studies that either underestimate or overestimate the number of radiation-induced casualties. As opposing camps fight to a standoff, consensus opinion is never achieved, and the public is left in bewilderment as to what really is the truth.

Given the formidable array of forces that delay or prevent a clear-cut assessment of the public health consequences of a radiation release, how do human beings in the immediate aftermath of environmental contamination arrive at an understanding of what has taken place? What tools do they have at their disposal for rapidly interpreting the event's impact? Public anxiety demands timely information. People are not going to wait patiently for decades to see if their health has been compromised. They want immediately to know how much radiation has been liberated into the environment, in what direction it dispersed, and if they should evacuate. They want to know about the safety of their food and water supply. They want to know who was exposed, what were their dosages, and what are the risks these dosages pose for initiating radiation-induced illnesses. How are answers to these pressing questions derived?

By this time, the answer to this fundamental question is self-evident: the risk factors! These are the lenses through which the ambiguities of a radiation emergency are brought into focus. They are the instrument used to structure the perception of a radiation release in the public mind.

As the history of radiation accidents has repeatedly demonstrated, the first response of representatives of the Cult of Nuclearists to a radiation emergency is to downplay or completely discount any potential threat. By this response, they attempt to avert panic, discourage social unrest and preserve confidence in the Cult's long-term nuclear agenda. To reinforce faith in the safety of nuclear technology, interpreters of the event — most often government spokesmen, apologists for the nuclear industry and media personalities — grab public attention and offer a sanitized version of the incident. Although radiation effects are profoundly difficult to discern and may take decades to decipher, these interpreters fabricate an instantaneously clear picture of what has transpired. This concoction, to attain credibility and be above suspicion, requires grounding on accepted scientific principles. This is where the radiation protection agencies enter into the scheme. Their science is recruited to legitimize the version of reality being invented. Elevated to the status of oracle, the risk factors are employed to divine the health consequences to the contaminated population. Following the protocols published by the radiation protection agencies, researchers mathematically model the radiation release. Based on estimates of the amount of radiation dispersed, the radionuclides involved, their chemical forms, prevailing weather patterns, dietary habits of the population, the number of people exposed and so forth,

dosages to the exposed population are *reconstructed*. On the basis of these *assigned* dosages, the potential types of illness and their frequency can be predicted based on the established risk factors. Without having to wait for decades to investigate what *actually* happened, a picture can be painted within hours or days of what supposedly will likely happen. Needless to say, the correctness of these speculations is wholly dependent on the accuracy of the assigned dosages and the fidelity of the risk factors.

The devilment lying at the heart of this elaborate charade is the authority bestowed upon the risk factors to accurately predict radiation effects. Consecrated by the high priests of the radiation protection community, the risk factors have been elevated to inviolable law. They are credited with the power of prophecy, foretelling the limits of the health consequences of released radioactivity. This point is essential to grasp. By sleight of hand, the portrait of a radiation event is painted by the risk factors. This is the image that reaches the public's awareness and shapes perception of the event. Distracted by this facsimile, the uninitiated fail to notice that the actual health toll remains undetermined or may be woefully out of sync with the whitewashed imitation.

The Cult of Nuclearists has built its castle upon the risk factors. To mollify concerns when radiation is released, the Cult of Nuclearists desperately requires an unassailable tool by which to paint a benign image of the event in the public consciousness. Groomed specifically for this purpose by the corrupted radiation protection agencies are the risk factors. These carefully crafted mathematical fictions are propaganda instruments designed to reassure a wary public that released radiation is no cause for alarm. They are the mask that disguises the plague unleashed upon the earth. The risk factors structure the perception that the guardians of radioactivity are adequately protecting the welfare of humanity. The public tolerates their mismanagement and mishandling of radioactive material based on their limited understanding of radiation effects and their trust in the accuracy of estimates of risk presented in the popular media.

This mischievous method of damage control is easily seen in the way that the radiation protection agencies are attempting to sanitize the Chernobyl catastrophe. By their approach, a dose is fabricated for a defined population, the risk factors are applied to this dose, and presto, the health toll of the accident immediately materializes out of nothing. To quote the ECRR:

> UNSCEAR 1993 gives the total committed effective dose from the Chernobyl accident to the world population as 600,000 person Sieverts. The ICRP risk factor of 0.05/Sv would predict 30,000 fatal cancers in the world from this; as UNSCEAR 2000 points out, such an increase would be statistically invisible.

As an exercise in epistemology, it is worth analyzing the meaning of this statement. UNSCEAR is not declaring that 30,000 fatal cancers will be produced from the accident at Chernobyl. What they are saying is something entirely different. They are saying something about their models, not reality. They are declaring that, according to their premises, the cancer fatalities that emerge at the other end of their equations is 30,000. BIG DEAL! We could start with different premises, apply other models, and arrive at different conclusions. In this manner, Gofman predicts 970,500 fatal cancers from external exposure to the single radioisotope cesium-137 released from Chernobyl. And the ECRR, employing its own models, predicts that over the next 50 years, in Belarus alone, an excess of 1,200,000 fatal cancers will occur, and worldwide, the total will reach 6,000,000. The conflict between different researchers is over models, not reality.

So, how many fatal cancers will **REALLY** occur as a result of the Chernobyl accident? No one on the face of the Earth has a clue!

Given this indeterminacy, the previous question needs to be reformulated: Who is in possession of the most *trustworthy* models for predicting radiation effects from Chernobyl? The Cult of Nuclearists ardently strives to convince the world that it is the ICRP, NCRP, NRPB, UNSCEAR, BEIR, and so forth. These are the organizations that have been sponsored and financed by the nuclear establishment and upon whom eminence and respectability have been conferred. Their version of reality is the one designed to be accepted by all inquirers. However, as we shall see in Exhibit F, when contaminated populations are investigated epidemiologically rather than mathematically, the rate of radiation-induced illness is greater than that forecast by the risk factors. This unfortunate intrusion of reality is the Achilles heel of the whole corrupted science of radiation effects and the slayer of the false models that have been intentionally crafted to underestimate the extent of injury suffered by humanity from nuclear pollution.

The risk factors have become so enthroned as the diviners of biological effects that they are frequently called upon to testify against observable health consequences that flatly contradict their accuracy. An excellent example is reported by Busby in *Wings of Death*. In the mid-1980s, the Committee of Medical Aspects of Radiation in the Environment (COMARE) concluded that radiation was not responsible for the confirmed leukemia cluster in the vicinity of the Sellafield nuclear installation first reported by Yorkshire TV. Despite the fact that the incidence of leukemia in the area was 10 times the national average, the committee insisted that radiation was not the causative agent. They justified their conclusion on the basis of the risk factors. Essentially, they said that given the *presumed* dosages, the observed leukemias could not possibly be radiation-induced because the risk factors did not predict them. In this instance, on the basis of the risk factors alone, radiation

was absolved of the responsibility of contributing to the obvious illness in the population. The committee was forced into upholding this dubious conclusion by an embarrassing dilemma. Confronted with the leukemia cluster, they were cornered into having to entertain one of two reasonable but politically unacceptable explanations. One, the dosages to the population were greater than modelled, perhaps due to unreported ventings of radiation from the facility. To endorse this conclusion would have called into question Sellafield's operating procedures. Two, the risk factors were in error. This determination would have compromised the credibility of the radiation protection agencies. To launder a potential threat to the credibility of the Cult of Nuclearists, the committee was left with no politically correct alternative other than using the risk factors to "prove" that the leukemia cluster was not caused by radiation exposure.

This issue is far from being just an intellectual game. It has real world repercussions that impact on human health. For instance, when the radioactive plume from Chernobyl was circling the Earth, citizens in the UK and the US received no warning of possible contamination to their food supply. This cavalier attitude was justified on the basis that the assumed accumulated dosages would be too low and that the risk factors applied to these dosages predicted that no threat to health existed. Evidence later surfaced that this presumption was woefully in error. In *Deadly Deceit*, Gould and Goldman provide convincing evidence that Chernobyl fallout was responsible for increased infant mortality in the US and significant increases in the death rate of the very old and those suffering from infectious diseases whose immune systems had been previously compromised. As will be revealed in Exhibit F, indisputable evidence also exists of an increased incidence of childhood leukemia in the US and the UK from the Chernobyl fallout which has been deemed by officials to have produced dosages too low to warrant concern.

The devastation of depleted uranium on the health of veterans and enemy noncombatants is destined to expose the lies buried within the science of radiation effects. All the major defenses of DU weaponry penned to date have been based on the models upheld by the radiation protection agencies. Researchers calculate the amount of energy deposited in tissue by different quantities of internalized uranium. The derived doses are then "proven" to be of no consequence to health, an opinion based ultimately on the data from Hiroshima and the resulting risk factors developed by the radiation protection agencies. This methodology cleverly avoids one essential ingredient: It fails to include actual epidemiological studies of groups exposed to depleted uranium who subsequently developed illnesses. Here again, the risk factors are being used as a smokescreen to draw attention away from any possible connection between radiation exposure and real illnesses suffered by real people. This game is played to convince all inquirers that depleted uranium is harmless. Given the rules of the game, this is the inevitable and logical conclusion. But the rules are about to change.

Once people awaken to the fact that the science of radiation effects has been intentionally corrupted, all conclusions as to the supposed harmlessness of low-level radiation in the environment will have to be reexamined.

"According to estimates of risk published by the radiation protection agencies, dosages to the population were too low to warrant concern!" Tirelessly, this refrain echoes around the world in the wake of every disclosed radiation release. Yes, we are told, mutagens and carcinogens have taken flight upon the winds, but no hazard exists, no one need be concerned. This carney game, played craftily for decades, is now an open book. The purpose of the Hiroshima Life Span Study is to define and delimit radiation effects in man. As this study matures, the data is continually massaged to produce conclusions acceptable to the Cult of Nuclearists. The types of illnesses observed in the Japanese study population and their frequency then become the basis for the risk factors developed by the radiation protection agencies. Studies are then sponsored by that Cult of Nuclearists designed to produce evidence that confirms the accuracy of the risk factors. Any investigators that produce results that call into question the veracity of the risk factors are vilified and marginalized; their work discredited and discounted for being outside the mainstream of "accepted" radiation science. Battle-lines form along any front that attempts to prove that more illness is produced in a population than that predicted by the risk factors. As long as the risk factors are upheld as an accurate depiction of reality, the swindle succeeds. When a new radiation event takes place, the tried and true damage control mechanism is activated. From the smorgasbord of scams rehearsed in this Exhibit, representatives of the Cult of Nuclearists pick and choose those most applicable to the situation. Artfully mixing together any number of the dosage scams, they contrive dosages for the exposed population that appear innocuous. By then applying the risk factors to these dosages, they "prove" that harm to public health was negligible or nonexistent. The hoax is artfully airtight.

A simple test should suffice to prove the truth or falsity of this allegation. ***If*** the Hiroshima Life Span Study is in fact honest, and ***if*** its findings can be applied to instances of internal contamination by radionuclides, and ***if*** the models of radiation effects promulgated by the radiation protection agencies faithfully mirror reality, ***then*** the risk factors should accurately forecast, within the limits of acceptable statistical error, the incidence of cancer in contaminated populations. If this is the case, no significant discrepancy should arise between the number of cancers predicted by the ICRP models and the actual number uncovered by epidemiological investigation. However, if the risk factors are shown to be inaccurate, what then? What if greater numbers of casualties are produced then those calculated by the accepted models of the radiation protection community? If evidence exists to this effect, then the whole house of cards of the Cult of Nuclearists comes tumbling down. It will prove that the risk factors, rather than being a tool in the service of

truth, are being used as an instrument of deception.

EXHIBIT F

The Cult of Nuclearists stands accused of perpetrating a fraud against the entire human race. Were the prosecution to rest its case at this point, the evidence presented in Exhibits A through E easily might be dismissed as toothless, theoretical arguments. Thus, before concluding, indisputable proof needs to be submitted to substantiate the charge that in many cases the risk factors for radiation induced disease are in error and the science of radiation effects has been intentionally corrupted. The information to be presented here will bear witness that the radiation protection community has allowed some monumental flaw to persist in current approaches to radiation safety, either through perpetuating defective models or a basic misunderstanding of radiation effects, ineffectual oversight as to the true extent of population exposure, insufficient epidemiological investigation or intentional malfeasance. When it is proven that levels of radiation in the environment deemed "permissible" are ruining human health, the science of radiation protection as currently practiced will stand exposed as counterfeit and duplicitous. This single crime has sired millions more, for it has given license to government and industry to deploy weapon systems and technologies that contaminate the Earth, invisibly sickening and killing untold numbers of unsuspecting victims.

According to the ECRR, there exists unequivocal evidence within the public domain that proves that the ICRP model of radiation effects is plagued by fundamental errors with regards to low levels of internal contamination. These errors lead to an underestimation of health detriment in the wake of a radiation release. The clearest example of these deficiencies surfaced after the accident at Chernobyl in 1986. As the clouds of fallout wafted around the planet, most governments broadcast reassurances to their anxious citizens that there was no cause for concern, that expected doses would be too low, *based on current standards of radiation protection*, to be medically significant. In most locales throughout the world, caution was not advised and people were informed that it was perfectly safe to continue to consume fresh meat and produce, dairy products, and unfiltered water from surface sources. This lackadaisical approach to radiation safety allowed the unnecessary internal contamination of unsuspecting bystanders and produced elevated rates of illness in many populations. What came to light in years subsequent to the accident was that children who received exposure to Chernobyl fallout, *while still in the wombs of their mothers*, experienced an elevated risk of developing leukemia by the time of their first birthday. In countries where unimpeachable data was collected for levels of fallout deposited in the environment, doses to the population, and the incidence of childhood leukemia, an unmistakable, uniform trend emerged: the cohort of children born during the 18-month period follow-

ing the accident suffered increased rates of leukemia in their first year of life compared to children born prior to the accident or to those born subsequent to the accident after the level of possible maternal contamination had sufficiently diminished. This was confirmed in five studies conducted independently of one another: in Scotland (Gibson *et al.*), Greece (Petridou *et al.*), the United States (Mangano), Germany (Michaelis *et al.*), and Wales (Busby and Cato). In calculations prepared by the ECRR, the probability that it was a chance occurrence that increased incidences of leukemia appeared in five different countries during the period of heaviest fallout from Chernobyl was less than 0.0000000001 (one in 10 billion). Low levels of internal exposure from Chernobyl was the indisputable cause of the childhood leukemia clusters.

In the UK, the National Radiological Protection Board measured and assessed the doses received by the populations of Wales and Scotland. Through environmental monitoring, they compiled data on the levels of Chernobyl fallout in the air, on the ground, and in food, milk, and water. Based on this information, they estimated the average level of exposure for members of the population. Plugging these dosages into their models of radiation effects, they calculated that no measurable harm was expected in the UK from the fallout of Chernobyl. To confirm or refute this assessment, Dr. Chris Busby and Molly Scott Cato undertook an investigation of the accuracy of the risk estimates of the NRPB as they applied to infant leukemia. Drawing upon the post-Chernobyl data collected by the NRPB and applying to it risk estimates for radiation-induced infant leukemia based on ICRP models previously published by the NRPB, they compared the expected number of cases of infant leukemia to the known incidence of childhood leukemia in one-year-olds born in the 18 months after the accident. This investigation was published under the title of "Increases in Leukemia in Infants in Wales and Scotland Following Chernobyl: Evidence for Errors in Statutory Risk Estimates." What Busby and Scott Cato discovered humiliated the pronouncements of the NRPB. The incidence of infant leukemia in the combined cohorts of Wales and Scotland exceeded that predicted by 3.8 times. According to the authors, *"Applying ICRP's risk factors to known levels of contamination from Chernobyl reveals 100 times less infant leukemia than actually found"* [emphasis added]. (As this cohort ages, further incidences of leukemia may prove that the accepted risk factors are even further off the mark.) The authors examined an alternative explanation, that the leukemias did not result from fetal exposure in the womb but from preconception exposure to radiation by the fathers. Under this scenario, the accepted risk factors were in error by approximately 2000 times. Simply stated, the NRPB models were proven to be in error. They substantially underestimated the hazard of the low levels of Chernobyl fallout on the health of developing children *in utero*. As stated by the ECRR:

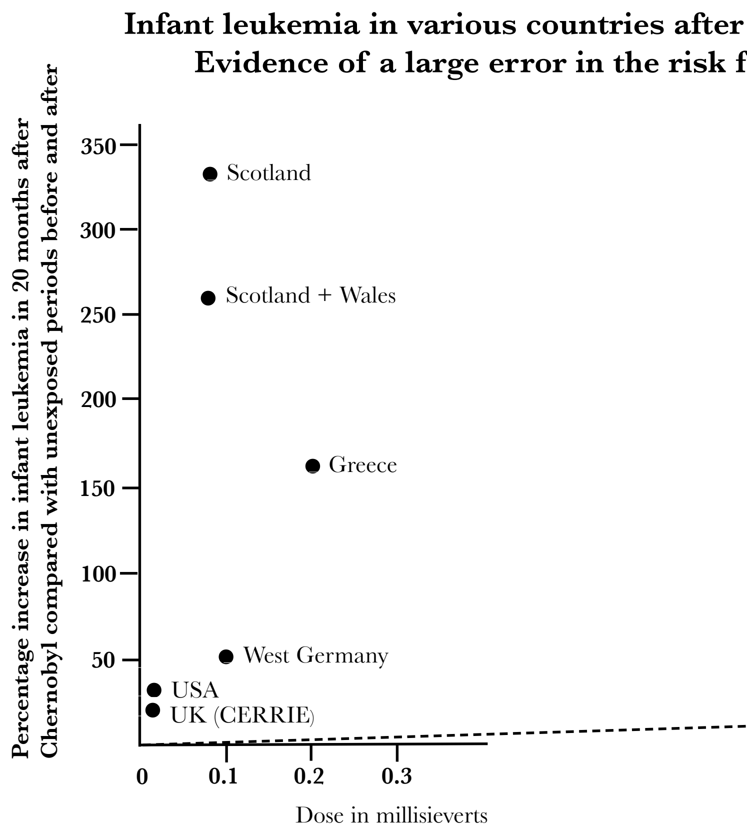
> The committee accepts that the infant leukemia results represent

> unequivocal evidence that the ICRP risk model is in error by a factor of between 100-fold and 2000-fold for the type of exposure and dose, the latter figure allowing for a continued excess risk in the cohort being studied. The committee notes that it will be necessary to follow the cohort as it ages.

Richard Bramhall of the Low Level Radiation Campaign analyzed the data on infant leukemia in Wales and Scotland after Chernobyl presented in the paper written by Busby and Scott Cato (Bramhall 2001). He made the following observation which further condemns the accepted models for radiation-induced childhood leukemia:

> In the case of infant leukemia, doses from Chernobyl should have produced far less than one additional case in the populations of Wales and Scotland. (To spare you the mental anguish of trying to imagine a fraction of a case of leukemia, I can tell you that all this means is that you'd have to investigate the cancer registrations for a population more than 50 times as big in order to expect even a single baby with leukemia caused by the radiation.)
>
> But Busby and Scott Cato looked at the figures and found that the rate had jumped quite sharply — 14 babies were diagnosed in the two years following Chernobyl. The average in a two-year period before it was 4.2, so finding 14 meant there were 9 or 10 extra cases.
> We don't know exactly how the radioactivity made these babies ill.
> Was it because it crossed their mothers' placentas?
> Or because it affected them after they were born?
> Or because the dose to their fathers' balls had mutated the sperm before they were even conceived?
> There are different risk factors for these different types of exposure routes.
> After doing some simple arithmetic with the figures in Busby and Scott Cato's paper we can display the implied errors like this:
>
> If the damage was done by the placenta-crossing dose, NRPB's prediction was about 72 times too small;
> if it was the postnatal effect, the prediction was 132 times too small;
> and if it was the preconception dose to the fathers' testes, NRPB was out by a whacking 2,390.

The Low Level Radiation Campaign (LLRC 2005) published this graph to visually



depict the disparity between the established risk factors for infant leukemia and the actual incidence of the disease from the five separate studies of the post-Chernobyl environment. The vertical axis of the graph represents the percentage of increase in cases of infant leukemia in the 20 months following the accident compared to the period before April 26, 1986 and the period after January 1988. The horizontal axis represents the doses, in millisieverts, received by the exposed population. It is important to note that these doses were derived from environmental monitoring of cesium fallout. Cesium, which emits highly penetrating gamma rays, is relatively easy to detect and its deposition over wide areas can thus be easily mapped. Monitoring this radionuclide provided investigators with a streamline method for estimating dosages to the exposed populations. According to the LLRC, however, this methodology may actually be flawed when determining the health effects produced from other radionuclides in the environment:

> But the very fact that it [cesium] is so penetrating means that its energy

> deposition (in the form of ionizations) is spatially well distributed in tissue, so its health effects are likely to conform with the external irradiation models. It is, moreover, soluble and does not form particles. The Chernobyl reactor fire produced other isotopes (including strontium-90) as well as microscopic particles of reactor fuel which traveled across Europe and beyond, exposing everyone in the path of the cloud to inhalation and ingestion. There is no reason why the health effects should conform with expectations based on cesium deposition.

The LLRC emphasizes that the doses, as shown in the graph, between 0.02 and 0.2 millisieverts represent levels below annual exposure to natural background radiation. The implication is that "dose" at this low level might not mean anything at all and that health detriment is produced by extremely low levels of internal contamination by radionuclides. Further, the infant leukemia data suggests that, far from being innocuous, natural background radiation may be the causative agent for some small fraction of human cancers. In the graph, the dotted line just above the horizontal axis represents the expected increase in infant leukemia according to currently accepted ICRP models *based on exposure to external radiation*. As the LLRC notes:

> [The dotted line] slopes up towards a point representing a 40% increase at a dose of 10 millisieverts. (This is five times natural background, and the graph would have to be almost a meter wide to show it). The origin of this yardstick is cancer deaths in children after their mothers had been X-rayed during their pregnancy.

The findings from Chernobyl flatly disprove the validity of this model. Doses much smaller than 10 millisieverts produced much greater increases in infant leukemia than were expected based on the yardstick mentioned in the quotation. Babies in Greece received a dose of only 0.2 millisieverts, and yet a 160% jump in the number of cases of infant leukemia was demonstrated there. Similarly, babies in Germany receiving a dose of 0.071 millisieverts showed an increased incidence of 48%. In Wales and Scotland, the doses were 0.08 millisieverts and the incidence of infant leukemia jumped over 200%.

Richard Bramhall has commented on the infant leukemia studies and compared the doses received from Chernobyl to those received by the residents of Seascale living near the Sellafield nuclear-fuel reprocessing facility. If the lower doses from Chernobyl produced elevated rates of infant leukemia, then this is indisputable evidence that the higher doses to the population from Sellafield pollution could have produced the cluster of infant leukemia in the vicinity of Seascale. Further, when the actual number of cases of infant leukemia is compared to that predicted by the currently accepted risk factors, the glaring inaccuracies

of current models come sharply into focus. According to Bramhall:

> In the parts of the UK mainly affected by Chernobyl fallout, the dose was about 80 microSieverts (i.e. 1250 times smaller than at Seascale); two separate studies showed [for infant leukemia] a 3-fold excess (Scottish infants) and a 3.6 excess (Scottish and Welsh infants combined). The implicit error in conventional risk factors is roughly 720-fold. In Germany there was a 1.6-fold excess and dose was 71 microSv (1400 times smaller than at Seascale). Implied error 450-fold. In Greece, there was a 2.6-fold excess and dose was 280 microSv (350 times smaller than Seascale). Implied error 300-fold. In UK data obtained by CERRIE, there was a 1.4-fold excess and the dose was 40 microSv (2500 times smaller than Seascale). We believe that these findings stack up to undermine ICRP's credibility.

Earlier in this chapter, it was mentioned that representatives of the Cult of Nuclearists vehemently deny that nuclear pollution from the Sellafield reprocessing facility is responsible for the cluster of childhood leukemia found in the nearby community of Seascale. Leukemia in the 0-14 year-old age group in Seascale shows a 12-fold excess compared with the rate of the disease for the UK as a whole. According to COMARE, on the basis of current models, the doses to the population were 300 times too small to be responsible for the observed incidence of leukemia. But look what the post-Chernobyl data has to say about this. It confirms that current models are incorrect to approximately this margin of error.

The infant leukemia produced by Chernobyl confirms that radioactive pollutants are the likely cause of childhood leukemia reported in the vicinity of Sellafield and of the other main sources of radioisotope pollution in Europe. Gardner *et al.* have confirmed a 10-fold increase in childhood leukemia near Sellafield. In proximity to the Dounreay reprocessing plant in Scotland, an eight-fold excess has been observed (Heasman *et al.*). A 15-fold excess in childhood leukemia has been reported near La Hague in France (Viel *et al.*). Near the nuclear facility of Harwell in Oxfordshire and the Atomic Weapons Establishment at Aldermaston in Berkshire, a two-fold excess in childhood leukemias were discovered. (Busby and Scott Cato 1997)

Rather than admit that the risk factors of the ICRP model are in error, representatives of the nuclear establishment in Europe have entrenched themselves in the position that the research is in error and that the infant leukemia clusters are a fabrication. How do they defend this position? They say that the "doses" in the vicinity of the studied nuclear facilities are simply too low to be responsible, based on the "accepted" risk models of the ICRP.

> All the analyses of causality in the case of nuclear site clusters rely exclusively on the ICRP risk model to show that the calculated doses to the children or their parents were insufficient to have been the cause of the disease since the linear ICRP model did not predict the leukemias or cancers. (ECRR)

According to the analysis of the ECRR, the numerous studies of childhood leukemia clusters in many parts of Europe confirm errors in the risk estimates of the ICRP models. When the doses to the population living in proximity to these installations are plugged into the model, wide discrepancies emerge between the expected number of cases of childhood leukemia and those actually observed. A 100 to 300-fold error in the risk estimates are evidenced by the leukemia clusters around Sellafield. A 100 to 1,000-fold error is observed from the clusters around Dounreay in the UK and La Hague in France. And a 200 to 1,000-fold error is apparent from studies of Aldermaston/Burghfield, Hinkley Point, Harwell and Chepstow in the UK, Kruemmel and Julich in Germany, and Barsebaeck in Sweden. From the 11 studies which it cites, the ECRR calculates that the probability that the excess leukemia is due to coincidence rather than being directly related to radioisotope pollution is less than 0.000000000001 (1 in one million million.)

> The confirmation of cancer and leukemia clusters in children living near nuclear sites has put considerable pressure on the scientific models of the ICRP and led to a dissonance between the model and observation that cannot be accommodated within a scientific paradigm (ECRR).

In 2007, the *European Journal of Cancer Care* published an article which further strengthened the conclusions reached by the ECRR. In "Meta-Analysis of Standardized Incidence and Mortality Rates of Childhood Leukemia in Proximity to Nuclear Facilities", Baker and Hoel confirmed that rates of leukemia in children are elevated near nuclear installations. Reviewing seventeen studies which covered 136 nuclear sites in the UK, Canada, France, the USA, Germany, Japan and Spain, the authors found that, depending on the distance of the child's home to the nuclear facility, the death rates from leukemia for children up to the age of nine were elevated between five and twenty-four percent. For children and adults aged zero to twenty-five, increased death rates ranged between two to eighteen percent. Regarding the incidence of leukemia, rates were elevated between fourteen and twenty-one percent in children zero to nine years old. When the age group zero to twenty-five was considered, the incidence rate of leukemia was elevated between seven and ten percent. Exercising caution, the authors couched there conclusions with this observation: "The meta-analysis was able to show an increase in childhood Leukemias near

nuclear facilities, but does not support a hypothesis to explain the excess." Relevant to the thesis of this chapter was the observation by Baker and Hoel that the **dose-response** studies they reviewed did not show excess rates of leukemia near nuclear facilities. **In other words, the current dose-response model fails to accurately depict reality.**

The significance of the infant leukemia clusters in the wake of the Chernobyl accident must not be lost on the reader. Radiation was delivered to developing fetuses through their mothers breathing and eating radionuclides that were released thousands of miles away. Levels of radiation in the environment where these women lived, declared by the radiation protection community as being below regulatory concern, adversely affected the development of their babies. This evidence definitively demonstrates that, at least for infant leukemia, the ICRP model is wrong. This model, based on instances of acute, high-dose exposure to external radiation fails to adequately account for illness induced by chronic low-dose exposure from decaying radioisotopes lodged within the human body's interior. The fact that the frequency of childhood leukemia occurred at a rate greater than predicted by the risk estimates derived from the ICRP model signifies that populations are incurring more illness from low-level radiation in the environment than the radiation protection community wants us to believe. An important corollary of this conclusion must never be forgotten. In the aftermath of many radiation releases, good epidemiological evidence is not always available. Consequently, the radiation protection agencies assess the impact to public health by turning to their models and allowing their models to inform the public of the cost they are paying in eroded health and death. When these models are flawed, they serve to cover up the true incidence of radiation-induced illnesses foisted on the population. Corrupted science becomes an accessory to murder. This is the fraud for which a guilty verdict is being sought against the Cult of Nuclearists.

The post-Chernobyl infant leukemia cohorts provide evidence that developing fetuses incur genetic damage from low-level radiation from internal emitters absorbed by their mothers. Although not proven, this evidence suggests that other types of genetic illnesses may likewise be traced to exposure in the womb to levels of internal emitters currently deemed inconsequential. In support of this hypothesis, Busby and Scott Cato cite evidence of other *in utero* effects in the immediate aftermath of Chernobyl. Data obtained from the UK Office of Population Census and Surveys provides evidence of babies with a very low birth weight — less than 1,500 grams (approximately 3.3 pounds) — born in Wales just after the accident. These births peaked between January 1987 and January 1988. (The Chernobyl accident occurred on April 26, 1986.) This evidence gives further credence to studies that demonstrated increased levels of infant mortality following exposure to fallout during the period of atmospheric weapon testing. In the light of these findings, it is essential to recall that, according to ICRP *models*, the radiation released into the environment by

humans has not been responsible for producing any fetal deaths, stillbirths, or death to infants. As the ECRR notes:

> The ICRP only considers heritable effects which are measurable in phenotype after birth e.g. congenital defects and perhaps increases in clinically diagnosed heritable genetic diseases. Thus fetal death and infant mortality are not addressed as radiation exposure outcomes by ICRP.

In addition to the research conducted on infant leukemia induced by Chernobyl fallout, the ECRR has identified a second body of research that unequivocally confirms that major shortcomings exist in the ICRP model of radiation effects. Again as a result of radiation vented from Chernobyl, data has been collected that proves elevated rates of minisatellite DNA mutations among exposed groups. Minisatellites are identical short segments of DNA that repeat over and over again in a long array along a chromosome. These stretches of DNA do not code for the formation of any protein. What distinguishes these minisatellites is that they acquire spontaneous repeats through mutation at a known rate, which is 1,000 times higher than normal protein-coding genes. Dr. Yuri Dubrova, currently at the University of Leicester, first realized that these stretches of DNA could be used to detect radiation-induced genetic mutations by showing that their known rate of mutation had increased subsequent to exposure. By this technique, only small population samples would be required to detect a trend in the rate of radiation-induced mutations. The accuracy of this methodology was first confirmed by Dr. Dubrova in mice. He then set out to investigate radiation-induced mutation in the human germ line — sperm and egg cells — among groups receiving exposure to Chernobyl fallout. That such mutation occurred in fruit flies and mice which was then passed on to their offspring had been known since the 1920s. That the same phenomenon occurred in humans had yet to be proven. Human germ line DNA is well protected against acquiring mutations. Most damage is immediately repaired. Irreparable damage frequently initiates cell death so that mutations are prevented from being passed on to the next generation. As a consequence, germ line mutations are rarely detected. The children of the atomic bomb survivors in Hiroshima and Nagasaki provided no evidence of any significant difference in mutation rates when compared to control groups.

Dr. Dubrova and his colleagues studied the rate of minisatellite mutations in families that had lived in the heavily polluted rural areas of the Mogilev district of Belarus after the Chernobyl meltdown. They found the frequency of mutations being passed on by males to their descendants was nearly twice as high in the exposed families compared to the control group families. Among those exposed, the mutation rate was significantly greater

in families with a higher parental dose. This finding was consistent with the hypothesis that radiation had induced the germ line mutations. It was the first conclusive proof that radiation produced inheritable germ line mutations in humans. The significance of this line of research was further confirmed by research in Belarus on the germ line mutations induced by Chernobyl fallout in barn swallows. (Ellegren *et al.*) Minisatellite mutations were observed and were accompanied by observable phenotypic alterations in plumage patterns as well as reduced rates of survival.

In 2002, Dr. Dubrova published further research in the journal *Science* concerning genetic mutation in populations exposed to fallout from atmospheric weapon testing. Between 1949 and 1956, the Soviet Union had detonated a series of aboveground atomic tests at the Semipalatinsk nuclear facility in Kazakhstan. The local population suffered significant radiation exposure throughout this period. The team led by Dr. Dubrova analyzed blood samples from three generations of about 40 families dwelling in the rural district of Beskaragai. They discovered a nearly 80-percent increase in the mutation rate in individuals directly exposed to the fallout in comparison with a suitable non-irradiated control population. The children of affected individuals evidenced a 50-percent increase in minisatellite mutations when compared to the children of non-irradiated parents. After the 1950s, when the practice of atmospheric weapon testing came to an end, the rates of mutation steadily declined.

Minisatellite DNA testing has also been performed on the children of Chernobyl "liquidators" i.e., those people who participated in post-accident cleanup operations. When the offspring of liquidators born after the accident were compared to their siblings born prior to the accident, a sevenfold increase in genetic damage was observed (Weinberg). As reported by the ECRR, "for the loci measured, this finding defined an error of between 700-fold and 2,000-fold in the ICRP model for heritable genetic damage." The ECRR made this further observation:

> It is remarkable that studies of the children of those exposed to external radiation at Hiroshima show little or no such effect, suggesting a fundamental difference in mechanism between the exposures [Satoh and Kodaira 1996.] The most likely difference is that it was the internal exposure to the Chernobyl liquidators that caused the effects.

This new body of data on minisatellite mutations provides unequivocal evidence that **radiation in the environment can induce alterations in the germ cells of human beings that can then be transmitted to offspring.** Due to current limitations in research techniques, the analysis of changes in the mutation rate of other parts of

the human genome has not yet been performed. The big question that remains to be answered is how frequently transmittable mutations occur in protein-coding segments of DNA and how often heritable diseases result from these mutations. Here, a whole new field of inquiry lies waiting to be explored. We must remove the blinders to our vision produced by the corrupted Hiroshima study. What has been considered in the past as hereditary disease might in fact be radiation damage to the germ cells of the parents, producing an array of chronic diseases in the next generation. At this point in history, we have no idea what portion of the inheritable diseases suffered by our progeny is being created by the radiation we have scattered throughout the biosphere. The CERRIE Minority Report offers this cautionary note:

> The question before the Committee is not whether such changes occur [minisatellite mutations] but whether they are associated with significant health detriment. In our view, repeat sequence mutations of various types have been associated with recognizable effects in humans, including neurological disorders, mental retardation, malformations, spontaneous abortion, epilepsy, diabetes, and cancers.

Observed health effects after Chernobyl have provided further evidence that the ICRP models are in error. For instance, research conducted in Sweden confirmed a 30% increase in the incidence of cancer between 1988 and 1996 as a result of the fallout from Chernobyl (Tondel *et al.*). In this study, dosages to the population were estimated on the basis of the deposition of cesium-137 in 450 parishes in northern Sweden and cancer rates were recorded for the 1,143,182 residents of the area. The 22,409 cases of cancer that were diagnosed during the nine-year study period presented an excess of 849 cases compared to what was predicted by ICRP models. According to analysis conducted by the Low Level Radiation Campaign, these excess cancers are 125 times the incidence predicted by the ICRP on the basis of the cesium doses. Due to the fact that this study was concluded nine years after the accident, LLRC warns that, due to the long latency period prior to the onset of cancer, future diagnoses are likely to demonstrate even greater error in ICRP models. If the observed effect up to 1996 is representative of the distribution of increased cancer risk throughout the lifetime of the study population, cancer incidence may prove to be more than 600 times that predicted by the ICRP. The LLRC has offered a further interesting observation about the Tondel study:

> The dose response trend calculated by Tondel on the basis of the various levels of cesium deposition is biphasic, not linear. In other words it does not conform with the ICRP dogma that dose and effect are always strictly proportional or "linear." The Tondel study does not show twice as much dose causing twice as much cancer.

> The doses given by Tondel *et al.* are calculated from cesium fallout. This may mean nothing since cesium is a gamma emitter which means that its energy deposition (in the form of ionizations) is spatially well distributed in tissue. It is, moreover, soluble and does not form particles. Its health effects are therefore likely to conform with the external irradiation models. However, it is well known that north Sweden received a large amount of fallout in the form of uranium fuel particles. With diameters of less than a few millionths of a meter such particles are highly mobile in the environment and they can be inhaled or swallowed. Once embedded in body tissue they deliver their energy so locally that the few cells immediately next to them are irradiated at very high energies while the rest of the body gets no dose at all. This makes nonsense of the concept of "average dose" – another establishment dogma (Bramhall, November 2004).

Under normal circumstances, thyroid cancer is a rare occurrence. After the core of the Chernobyl reactor became scattered to the winds, however, an epidemic of thyroid cancer among children and teenagers broke out in the most affected Soviet territories. For example, Stsjazhko *et al.* reported in 1995 on the officially validated rate of thyroid cancer in Belarus in the under-15 age group before and after the accident (2.8 million children fell within this group out of a total population of 9.9 million.) In the years 1981 to 1985, approximately 3 cases of thyroid cancer existed per million children. In the years 1986 to 1990, the number of thyroid cancers had increased to 47 per million — 17 times the pre-accident level. Between 1991 to 1994, 286 cases per million were validated — 102 times greater than before the accident.

This epidemic was beyond the purview of the ICRP risk models. Ignoring the tragedy of the Marshall Islanders, the prevailing view of the cancer-causing potential of internalized iodine-131 was given clear expression in UNSCEAR 1988. The authors stated that their literature review provided "little proof that iodine-131 is carcinogenic in humans and support[ed] the notion that the carcinogenic potential of I-131 beta particles might be as low as four times less than external x-rays or gamma rays." Here in a nutshell is expression of the corrupted paradigm of radiation effects: external radiation is more hazardous than internal contamination and the risk to health is extremely diminished if the exposure is chronic rather than acute. According to the ECRR, these two errors were demolished by the high rate of thyroid cancer after Chernobyl. First, internal contamination, not external irradiation, caused the runaway epidemic. Second, chronic low-dose exposure from radionuclides in the environment was the method of delivery. Further, Chernobyl refuted the prevalent idea that a latency period of 10 years or more was required between thyroid exposure and the onset of clinical symptoms. After the Chernobyl explo-

sion, increases in the rate of thyroid cancer became observable within a few years.

To fit the skyrocketing incidence of thyroid cancer to their incorrect models, the radiation protection agencies attempted to massage their data:

> The risk agency community, having had to swallow the facts of the increase, promptly responded by adjusting the doses to as high a level as possible to try and fit the data to the model. The idea was to assume that the children who were affected had been iodine-deficient and therefore their thyroid glands would take up more iodine. This was unsuccessful since doses large enough to fit the cancer data would be so high that the children would have died of radiation sickness (ECRR).

In his book *Wings of Death*, Chris Busby provides an excellent example of the type of shenanigans that can infiltrate the field of radiation protection. It is mentioned here because it bears on the accepted risk factor for thyroid cancer and the reason for the inaccurate predictions made for this endpoint in the wake of Chernobyl. Both BEIR V and UNSCEAR 1988 cite a study by Lars-Erik Holm and colleagues on iodine-131 induced thyroid cancer. (The UNSCEAR document referred to the study as "important evidence." Lost to many in the fine print was the fact that Holm was one of the authors of UNSCEAR 1988.) The development of the accepted risk factor for thyroid cancer relied heavily on this study. Holm *et al.* conducted research on a population of 35,000 patients, who between 1951 and 1969 had undergone diagnostic procedures that involved injections of iodine-131. In determining the incidence of radioiodine induced thyroid cancer, the authors made a scientifically questionable procedural decision. They discarded from consideration all cases of thyroid cancer that had been diagnosed within five years of the I-131 injections. They justified this extraordinary step on the basis of the Hiroshima Life Span Study, that claimed that a considerable time elapsed between exposure and the clinical expression of thyroid cancer. Assuming the truth of this observation to be applicable to all avenues of exposure, the authors concluded that cancers diagnosed within five years of exposure could not be reliably attributed to the radioiodine injections. They proceeded on the unwarranted premise that these cancers were present prior to the injections but had gone undiagnosed. From a study of the control population, the authors calculated that in a population of 35,000 the expected number of thyroid cancers would be 39.4. After discarding the questionable cancers appearing within five years of injection, 50 cancers were recorded in the study group. This number was not statistically significant when compared to the control population, and the conclusion the authors arrived at was that the internalized iodine-131 had no effect on the incidence of thyroid cancer. How many cases of thyroid cancer

did they need to throw out to reach this conclusion? As Busby reports: "Careful analysis of the paper reveals that 156 extra cancers developed in the group in the first five years but that these were discarded. The true result should have been 156 + 50 = 206 cancers, or five times the control group incidence (Gofman 1990)" (Busby 1995).

By this time, the reader needs little coaching to discern the scam being enacted, perhaps unwittingly, by scientists enmeshed in the bastardized system of radiation effects. Holm and colleagues ground key ideas of their research on the corrupted Hiroshima data of acute, external irradiation that purportedly "proved" that thyroid cancer requires a long latency period. They then imported this "fact" into a study of internal contamination by iodine-131 and used it to justify throwing out 156 cancers from their study group. This permitted them to reach the conclusion that internalized radioiodine does not contribute to excess thyroid cancers. At this point, the radiation protection agencies step in and use this "important evidence" to establish risk factors for iodine-131. In the event of a radiation accident that vents radioiodine into the environment, the radiation protection agencies can refer to what by this time has gained the stature of a canon, in order to bamboozle the population into believing that the public health impact will be much less severe than what actually transpires. In the event that anyone questions the accuracy of these authoritative assessments, they will be referred to the mind-numbing Gordian Knot of indecipherable journal articles, cryptic mathematical models, and unconquerable decrees of the ICRP: the *modus operandi* of a near-perfect crime. One can only marvel at the sophistication of this debauched edifice, which masterfully conceals mass casualties and death delivered to the people of the Earth by the Cult of Nuclearists.

The severity of the Chernobyl accident caused this corruption to be unveiled. Using data from Belarus that was reported in UNSCEAR 2000, the ECRR calculated that the error in the risk factors of the ICRP for thyroid cancer was about six-fold or more. In confirmation of this conclusion, *Wings of Death* contains the following observation:

> It is clear, nevertheless, that a major error exists in the accepted risk for thyroid cancer. There are already 450 cancers in the first 10 years for the under-14 age group alone in the areas into which the evacuees [from Belarus] were moved. Only 100 excess thyroid cancers were predicted for all age groups combined in this population for the next 50 years. Thyroid cancer has also increased in adults. In 1993 there were 2,039 registered cases in Belarus (population 10.5 million) and more than 3,000 in the Ukraine (population 53 million) (BMJ, 1993). At minimum the error defined by this is already several hundred per cent; at maximum it is truly enormous, since only 10 years have passed out of the 40 years covered by the prediction. The trend is

> upward: this error will grow. These predictions were made on the basis of the existing risk factors, so their inaccuracy, already apparent and no doubt to become more obvious over the coming years, indicates that the risk-factor calculations for thyroid cancer, like those for leukemia, are unreliable. Chernobyl represents the most important recent test of these risk factors; it has proved that they are in urgent need of revision (Busby 1995).

Before proceeding, it is worthwhile to digress for a moment to explain how inaccurate risk factors for internal contamination have been able to endure. The radiation protection agencies are responsible for perpetuating a number of dogmatic ideas concerning radiation effects in man. Students of the radiation sciences are indoctrinated with these ideas and have no reason to question them. These ideas have a powerful influence on the thinking of researchers and have caused otherwise sincere and scrupulous scientists to reject data that is out of sync with so-called "conventional wisdom." By this means, the knowledge base of radiation effects is severely constrained. The authors of the CERRIE Minority Report have identified a number of the presumptions that have held sway over radiation epidemiology and prejudiced the outcome of so-called "definitive" studies of the effect of radiation on human health. These include the following:

1. In response to expectations inherent in the ICRP's models and risk factors, a large range of epidemiological studies of internal radiation have been dismissed. Rejection of this data is justified on the grounds that it is not in harmony with what is presumed to be unassailable scientific fact.

2. Radiation effects in populations are assessed through the prism of the Linear No-Threshold Hypothesis. Those who receive the highest dosages are presumed to be the ones that will manifest the greatest effects. If evidence is gathered that shows that the greatest effects are suffered by those with less than the highest dosages, this evidence is considered suspect and frequently rejected. The hidden assumption in this is that **ALL** endpoints of radiation-induced damage is linearly related to dosage. This certainly may not be the case with certain endpoints created by internal contamination. For instance, in the case of infant leukemia after Chernobyl, populations receiving the highest dosages may not have exhibited the highest incidence of infant leukemia because of an increase in spontaneous abortions, fetal deaths or still births.

3. In most incidents of radiation exposure, populations receive a mixture of external irradiation and internal contamination. However, by convention, the dosages of those exposed are almost invariably defined in terms of the dose delivered externally. In this way,

the health effects produced by the internal contaminants are either missed entirely or not adequately studied.

4. Frequently, simplistic assumptions are made about how radioactivity, once liberated, migrates through the environment, which groups receive exposure and the dosages received by those exposed. These "assumptions" color the outcome of epidemiological studies and prejudice the "objective" findings of a study.

5. Only certain disease endpoints are assumed to be radiation-induced, namely cancer, leukemia, and genetic disorders. Other possible endpoints receive no attention. This cocksure assumption has presented a severe obstacle to the investigation of the role played by depleted uranium in the etiology of Gulf War Illness.

Currently, an epidemic of cancers is ravaging the health of people in many parts of the world. In response, a highly contentious debate has arisen over the contribution played by fallout from nuclear weapon tests to this scourge. The Cult of Nuclearists rigidly adheres to the position that fission products, now ubiquitous in the environment, do not contribute significantly to people's yearly doses from natural background radiation and cannot possibly be a health hazard. They base this assessment on their biologically questionable concept of dose, the total amount of energy deposited in the body by radiation. They give scant attention to the reality that the radionuclides from weapons tests, which we all carry within our cells, may decay while in proximity to a cell's genetic material and disrupt that cell's programming for healthy functioning. Under this scenario, the biological effect might be totally unrelated to the total amount of energy absorbed.

In 1993, using models of the ICRP, UNSCEAR published calculations of the average committed effective doses in person Sieverts from fallout to world populations. According to their tabulations, the amount of fallout radiation released on the Earth since 1945 and stretching infinitely into the future due to the decay of long-lived radionuclides, totals 29,800,000 person Sieverts. Applying to this number the ICRP risk factor for fatal cancer of 0.05 per Sievert yields the estimate that fallout from weapon testing will be responsible for ultimately producing 1,500,000 cancer deaths. As mentioned elsewhere, this number is totally dependent on the assumptions and models upheld by the ICRP. Using different models which attribute greater biological effect to internally incorporated radionuclides, the ECRR estimates that 120,000,000 radiation-induced cancers will be diagnosed, with 60,000,000 of these being fatal. In other words, the so-called nuclear superpowers, flaunting their nuclear machismo, have already committed crimes against humanity, and World War III hasn't even started yet. With talk of a new, fourth generation of nuclear weapons, mini-nukes, micro-nukes, nuclear bunker-busters and so forth, the human guinea

pigs of the world must not be lulled into forgetting that these weapons release vast quantities of radionuclides that migrate freely around the globe.

In their review of the literature, the ECRR examined 10 studies of cancer incidence in the wake of fallout from nuclear weapon tests. They assert that evidence exists that global fallout has produced infant mortality and increases in the rate of cancer, leukemia and other diseases of genetic origin. They make a very convincing argument that the cancer epidemic of today can be sourced to the nuclear contamination of the Earth that occurred decades ago. According to the ECRR:

> In reaching this conclusion, the committee has been impressed by the lack of evidence as to the origin of the global cancer epidemic which began in the period 1975-85. Cancer is now widely seen, in the medical community, as a genetic disease expressed at the cellular level, and both early and recent research have supported the idea that the origin of the disease is essentially environmental exposure to a mutagen. If cancer rates began to increase sharply in the period 1975-1985, and since research has shown that the disease is known to lag the exposure by 15-20 years, clearly, the origin of the epidemic must be the introduction of some cancer-producing mutagen into the environment in the period 1955 to 1965. The identification of the mutagen with ionizing radiation from weapons fallout is persuasive. In addition, the variation in cancer incidence rates across regions of high and low rainfall and deposition points to radiation as the main cause of the cancer epidemic.

Nuclear weapon testing vented an enormous quantity of radionuclides into the atmosphere. Since rainfall washes radiation out of the air, the presumption is made that people living in high rainfall areas received greater doses of this radiation than people living in low rainfall areas. To gauge the impact of fallout radiation on health detriment, a number of studies have been conducted comparing the rates of cancer in high and low rainfall areas. As reported by Busby in *Wings of Death*, when cancer rates in Wales (high rainfall) were compared to rates in England (low rainfall), a high correlation was discovered between cumulative strontium-90 exposure of between 0.2 and 1.0 mSv over the period of fallout and the trend in Standardized Incidence Ratios for all malignancies in Wales 20 years later. According to the CERRIE Minority Report, "The error in ICRP implicit in this correlation is 300-fold."

The ECRR relates an interesting story with regard to the search for correlations between atmospheric weapon testing and childhood cancer. During and following the period

of aboveground weapon detonations, a disturbing increase in childhood cancers, notably leukemia and brain cancer, began to be noted. In an attempt to provide an explanation for this trend, the hypothesis was advanced that fallout, perhaps strontium-90, occurring in milk, was responsible. In the UK, the Medical Research Council was asked to make a study of this hypothesis. The council reported, on the advice of the epidemiologist Sir Richard Doll, that according to the data from Hiroshima, fallout could not be the cause of the childhood cancers because the *doses* were too low. In 1994, Doll, with a number of other researchers (Darby *et al.*), published a famous study concerning the relationship between childhood leukemia and fallout in Nordic countries. They discovered a modest increase in the incidence of the disease during the period 1948-58 and 1965-85, from 6.0 cases per 100,000 to 6.5 cases. This increase was deemed insignificant. According to the ECRR, this study is frequently cited as proof that low doses of internal radiation produce no adverse affects on health. Since then, the study has been reexamined and found to be riddled with errors that prejudiced the conclusions. (An extensive discussion can be found in Busby's *Wings of Death*.) The first error was that the rates of childhood leukemia in the five Nordic countries of Denmark, Norway, Sweden, Finland, and Iceland were pooled together despite the fact that, due to different rainfall patterns, doses to the populations would not be uniform. Further, the populations had different eating habits and different genetic make-up. These differences invalidated the methodology of pooling the data. The second error was that no data of childhood leukemia were presented for any time prior to the study period. (A study in the UK by the Medical Research Council, co-authored by Richard Doll, displayed unequivocal evidence of a rise in the rate of childhood leukemia corresponding to the beginning of atmospheric detonations of atomic bombs.) The third error was catastrophic to the study. The leukemia data for the period 1948-58 was drawn exclusively from the Danish Cancer Registry. This was then compared, for the period 1965-85, with the pooled data from the five Nordic countries. No mention is given in the paper that the study population changed halfway through the study! Only by these monumental errors were the authors of the Nordic Leukemia Study able to conclude that the risk factors of the ICRP for childhood leukemia were essentially correct.

The ECRR states that when the pooled data of the five Nordic countries is correctly compared for the period under study, leukemia in children 0-4 years old increased from about 5.0 cases per 100,000 to 6.5 cases. This was an increase of about 30%. Concerning this increase, the ECRR makes the following observation:

> The leukemia incidence increase of 30% in the children exposed over the 5-year period [1958-63] followed a cumulative dose of between the 0.15 mSv bone marrow dose received in utero and the 0.8 mSv received between ages 0 and 4. This suggests an error in the ICRP

> risk factor (of 0.0065 per Sievert, for children) of between three and 15-fold if no further excess leukemia occurred in this cohort and an error of between 40 and 200-fold if this excess risk continued throughout their lives. In this respect it is of interest that a similar proportionate increase of about 30% occurred in the trend in Standardized Incidence Ratio of 'All Cancers' in England and Wales some 20 years after the exposure.

The CERRIE Minority report mentions a study by Bentham and Haynes of childhood leukemia in England and Wales after weapons fallout. The researchers stratified different geographical areas by rainfall exposure and studied the correlation between this exposure and rates of leukemia. A 25 percent excess in the disease was observed in high rainfall areas relative to areas of low rainfall. This observation is in agreement with the revised data of childhood leukemia in Denmark and supports the conclusion that an error of greater than 100-fold exists in the currently accepted risk factors.

Further cracks in the ICRP barricade against truth have surfaced as a result of research conducted on nuclear workers. The ECRR mentions a study conducted by Roman *et al*. of prostate cancer risk in nuclear workers who were monitored for internal contamination. Results suggested an error of up to 1000-fold in the ICRP model for this disease. The CERRIE Minority Report cites a study by Beral *et al*. of prostate cancer in UKAEA workers, which provided evidence that the risk factors for a number of radionuclides including zinc-65 and tritium were in error by at least three orders of magnitude. The Report also mentions in passing a number of other studies of nuclear workers that revealed greater numbers of cancer than those predicted by the ICRP risk factors. These were conducted by Carpenter *et al*., 1998; Muirhead *et al*., 1999; Draper *et al*., 1997; and Omar *et al*., 1999. Of these studies, the CERRIE Minority makes an interesting observation: "*Many of these effects in nuclear workers have been discounted by the authors on the basis of their failure to conform with a linear dose response relationship*." This is truly startling. Rather than trust the veracity of their data, researchers will discount findings that are in violation of established dogma, never questioning that the dogma itself might be based on faulty premises. In the case of low levels of internal contamination, as this work has attempted to demonstrate, there is no evidentiary basis for the belief that biological effect is linearly related to the quantity of energy deposited in tissue.

When confronted with evidence that radionuclides emitted from nuclear installations do cause leukemias and other cancers, nuclear apologists parry the attack with the observation that those studies which do demonstrate a correlation between radionuclide exposure in the environment and illness involve relatively small population samples and the

frequency of observed illnesses are not statistically significant. In many cases, this is a valid criticism which, for over half a century, has successfully prevented liability being assigned to those who discharge radiation into the environment. However, as research continues to accumulate, this position is becoming increasingly less tenable. Although small studies may produce statistical anomalies that fail to prove a rule, the cumulative power of numerous small studies, all confirming heightened incidence of childhood leukemia and cancer in contaminated areas, has to be respected as evidence that some real effect is being observed.

In Europe, a number of epidemiological studies have been carried out to examine the relationship between nuclear pollution and ill health. In geographical areas where isotopes have been found to accumulate, the local inhabitants have consistently faced greater risks of developing leukemia and cancer than predicted by ICRP models. Coastal communities in Ireland and Wales in proximity to the Irish Sea have been investigated due to the accumulation in that body of water of fallout, discharges from nuclear fuel-reprocessing (Sellafield) and dumping of radioactive waste (Sellafield and nuclear reactor facilities.) Along certain shorelines, radionuclides — most notably plutonium-239, cesium-137 and strontium-90 — have contaminated mudbanks, estuaries, and intertidal sediment (the sediment lying between high tide and low tide marks). Studies have shown that the radioisotopes discharged into the Irish Sea bind preferentially to fine silts. While afloat on the water surface, the action of wind and waves resuspends this fine particulate matter and blows it ashore. Alternatively, radioactive sediment trapped in the intertidal zone during low tide dries and is swept into the air by wind. In either case, the end result is that radionuclides from the sea contaminate inland air where it is available for inhalation by populations living along the coast. This hypothesis is supported by a number of observations. Airborne plutonium was collected in muslin screens set at various distances from the Irish Sea. The highest concentration of plutonium was found in those screens closest to the coast with a rapid falloff occurring within a few kilometers inland and then flattening out further into the interior. Analysis of plutonium in deciduous teeth showed the same gradient. Residents close to the coast bore a higher burden of plutonium contamination in their teeth than their neighbors living slightly further inland. As distance from the coast increased, plutonium concentrations decreased. A study of plutonium concentrations in sheep feces bore witness to the same phenomenon. Another study looked at the concentration of plutonium and cesium-137 in autopsy specimens. Again, a correlation was established between the distance of a person's home from the Irish Sea and the extent of the body burden of contaminants. In this study, it was observed that the highest levels of radionuclides were found in the lymph nodes draining the lung, suggesting that inhalation was the route of exposure. This evidence of differential exposure to radiocontaminants diminishing with distance from the Irish Sea strongly suggests that sea-to-land transfer is the best explanation for the phenomenon. This radioactivity in the environment correlates with observations of a high

incidence of cancers in certain coastal communities. In Ireland, a significant excess of childhood leukemia was discovered in a strip three miles wide along the east coast (Busby *et al*., 1998). An excess of breast cancer was also observed among Irish women living close to the coast (CERRIE Minority Report.) As noted in the CERRIE Minority Report: "The trends in cancer risk by distance from the sea correlated well with inland penetration by sodium chloride and concentrations of plutonium in air as measured by Harwell [Nuclear Research Establishment] workers in the late 1980s (Easkins and Lally 1986)."

The period of peak emissions from Sellafield, coinciding with the highest level of radioisotope pollution along the coast of Wales, occurred between 1974 and 1989. According to the Green Audit Irish Sea Research Group, the incidence of cancer in Wales for most age groups was significantly higher among people living in population areas centered within a 800-meter wide strip stretching along the coast of the Irish Sea. Compared with the combined population of England and Wales, a 4.6-fold excess of leukemia in 0-4 year olds was discovered in this coastal area (Busby *et al*., 1998). The risk of contracting cancer was found to fall off as one moved west from the coast, first of all falling sharply, then showing a slight rise inland at the mountains, and then steadily decreasing toward the border with England where rates then became comparable with English rates.

A very dramatic cluster of cancers has been discovered along the Menai Strait between the island of Anglesey and North Wales. Mud banks in this area are known to be heavily contaminated by radionuclides discharged from Sellafield. As reported by the Low Level Radiation Campaign:

> In the seaside town of Caernarfon, leukemia in the 0-4 year-old age group is more than 20 times higher than the UK national average. Brain cancers in the 0-14 age group are 18 times the average. Elevated risks not confined to the town — the 34 wards surrounding the Menai Strait - have:
>
> * an eight-fold excess of leukemia in children younger than 4
> * a five-fold excess of brain and spinal cancer in children younger than 15
> * a 10-fold excess of retinoblastoma in children under 14.
> (Retinoblastoma, a rare eye cancer, has been associated with radioactivity since the Seascale cluster of leukemia is accompanied by a 20-fold excess of retinoblastoma in children of Sellafield workers) (LLRC 2004).

These findings are highly relevant to the current discussion. Britain's Committee of

Medical Aspects of Radiation in the Environment (COMARE) investigated the reported childhood leukemia cluster in the environs of Seascale, near the Sellafield reprocessing plant. Repeatedly, they advised that, according to the current knowledge base, *doses* to the surrounding population from Sellafield were too low to be responsible for inducing the observed illnesses. The even more dramatic cluster of childhood cancers along the Menai Strait serves as a powerful indictment of COMARE's objectivity and its assessment of Sellafield's innocence. What it does is offer further confirmation that radioisotopes released from this reprocessing facility are inducing cancer in children. This newest revelation of the relationship between radiation in the environment and cancer screams out, once again, that there is something terribly suspect in what is currently embraced as the "truth" about the risks to health posed by internal exposure.

In Europe, other nuclear facilities besides Sellafield have been found to be inducing illness in their neighbors. Clusters of childhood cancer and leukemia have been discovered in communities near the nuclear reprocessing facility at Dounreay in the far north of Scotland. Research undertaken in 1986 revealed that childhood leukemia within 12.5 km of Dourneay was 600% higher than the average incidence elsewhere in Scotland (Busby, *Wings*). As at Sellafield, COMARE confirmed that this excess was real, but denied that it was the result of nuclear pollution, on the grounds that the currently accepted dose-response models could not account for it. Another cluster of childhood leukemia in the United Kingdom was identified in the region close to the Atomic Weapons Research Establishment at Aldermaston in Berkshire. The excess was observed in children under five years old who lived within 10 km of the facility (Beral 1993). According to the CERRIE Minority Report: "these well-documented effects indicate a potential for the existence of errors in the ICRP risk model of between two and three orders of magnitude."

The Hinkley Point nuclear power plant is located near Burnham-on-Sea in Somerset, UK. The first reactor came online in 1964. That the plant was contaminating the surrounding area was confirmed in subsequent years with the discovery offshore of radionuclides adhering to fine sediments in the Steart Flats mudbank. To discover whether or not this pollution was harming the local population, the Somerset Health Authority in 1988 undertook a study of the incidence of leukemia in parishes within a 15 km radius of the plant. The study confirmed that, during the period 1959-1986, a significant increase occurred in the incidence of leukemia and non-Hodgkins lymphoma among people younger than 25 years of age (Green Audit). The relative risk, driven by a high number of cases occurring in the first five years of the plant's operation, was between 2.0 ad 2.5 times the national average. For the period 1995-1999, breast cancer mortality in Burnham-on-Sea was twice the national average. Evidence that Hinkley Point pollution was responsible for this increase was made obvious by this observation from the researchers who discovered

this increase:

> Our first analysis of the Hinkley Point area was for breast cancer mortality. Results supported the hypotheses: analysis showed that there was a statistically significant excess risk of dying of breast cancer in the aggregate wards within 5 km of the center of the offshore mud banks near Hinkley Point (RR=1.43; p=0.02). The risk fell off with increasing distance from a point source taken to be the center of the mud bank with Relative Risks of 1.43, 1.33, 1.24, 1.16 and 1.13 in wards contained within 5, 10,15,10 and 25 km rings around the point source. The overall risk in the study area was 1.09 (relative to England and Wales rates for the same period). The most significant high risk ward was Burnham North with 8.7 deaths expected, 17 observed (RR=1.95; p=0.02).
>
> We followed this by analyzing risk of dying of prostate cancer (Busby *et al.*, 2000b). This also supported the hypothesis. As with the breast cancer, prostate cancer mortality showed a significant trend with distance, falling from 1.4 in the 5 km ring around the center of the offshore mud banks to 1.02 in the 25-30 km ring (Chi square for trend 3.47, p = .05). Again, the downwinders at Burnham-on-Sea suffered a significantly raised cancer mortality risk: for prostate cancer mortality in the two wards, Burnham North and Burnham South combined, the Relative Risk was 1.5 with p = 0.05 (14 expected, 21 observed) (Busby, Dorfman, Rowe).

In the UK, HM Dockyard Plymouth services nuclear submarines. When the decision was made in 2000 to increase capacity, Devonport Management Limited, which operates the facility, applied to the Environment Agency to be allowed to increase its annual emissions of radionuclides. A 700% increase, from 120 GBq to 800 GBq, was proposed for tritium discharges into the Tamar River, which flows past Plymouth. In addition, permission was sought for raising tritium discharges into the atmosphere from 1 to 5 GBq together with a new requirement for releases of 45 GBq of carbon-14 and 15 Gbq of argon-41. This proposal raised concern among local citizens. One question that many people sought an answer to was the health effects, if any, caused by the lower levels previously permitted. In response, the South West Devon Health Authority (SWDHA) issued a report on leukemia in the Plymouth area, based on figures provided by the South West Cancer Intelligence Unit. According to the report, a statistically significant excess in leukemia incidence of 25-30% was present for the period 1995-1997, for both men and women of all age groups. However, the SWDHA report concluded that these increases were not related

to radionuclide discharges from the dockyard. Their reasons, according to *Cancer and Leukemia and Radioactive Pollution from HM Dockyard, Plymouth* was: "(a) the crude death rates from leukemia were not highest in the wards closest to the dockyard, Keyham [on the east side of the Tamar near the dockyard] and Torpoint [on the western side of the Tamar, opposite the dockyard], and (b) radiation exposure from the releases were too small to cause any measurable increases in leukemia (Busby and Avent)." To prove (a) as false and (b) as an invalid assumption based on incorrect risk models of the ICRP, Plymouth's Campaign Against Nuclear Storage and Radiation (CANSAR) and the environmental group Green Audit conducted research on the incidence, *not death rate*, of cancer and leukemia in Keyham and Torpoint. The results of their study confirmed that in the 10-year period 1994-2003, there was an 18-fold excess risk of leukemia in Keyham (seven reported cases where only 0.38 were expected based on national rates) and a 4.7-fold excess in Torpoint (four cases reported where only 0.84 were expected.) To add greater strength to the findings, a proportional incidence analysis was carried out in which the ratios of leukemia to all cancers were determined and compared to the ratio for the country as a whole. Again, an excess incidence of leukemia in the two wards was confirmed. The risk for all cancers combined was also elevated. In Keyham, for all ages, there were 39 cases of cancer reported when the expected number was only 20. In Torpoint, there were 76 reported cases where only 45.8 were expected. These results confirmed the excess leukemia risk in the vicinity of the Plymouth dockyard. Further, they drive another nail into the coffin of inaccurate risk factors that leave leukemia incidence near nuclear installations unexplained.

The finding of an excess incidence of leukemia in areas near nuclear installations is not confined to the UK. A 15-fold excess in the incidence of childhood leukemia has been discovered near Cap de la Hague, France's nuclear fuel reprocessing facility (Viel *et al.*). In this study, it was determined that the two excess risk factors for children were playing on the beach and eating shellfish. In a separate study, childhood leukemia within a 10 kilometer radius of the plant was six times the expected rate (Guizard *et al.*). In northern Germany, a similar discovery was made. In children 0-4 years of age living within five kilometers of the Krummel nuclear power plant, a five-fold relative risk of leukemia was observed. This jump in leukemia incidence appeared five years after the plant began operations in 1983. A significant increase in adult leukemia in proximity to Krummel was also observed. Elevated levels of chromosome aberrations in the blood of local residents further supported the hypothesis that radiation was the causative agent for the leukemia cluster (Ziggel *et al.*, 1997). Environmental monitoring detected the presence of artificial radioactivity in air, rainwater, soil and vegetation, confirming chronic leakages of radioactivity from the facility. Calculations applied to the observed levels of radioactivity in the environment implied that emissions from the plant must have been well above authorized annual limits. In a separate study conducted by Korblein *et al.*, a statistically significant increase in *all* types of

childhood malignancies was discovered in children, ages 0-4, who lived in the areas closest to *all* commercial nuclear power plants in Germany. These findings remained unchanged when statistics for the area around the Krummel plant, with its confirmed leukemia cluster, were excluded.

In 1995, Iwasaki *et al*. published data concerning leukemia and lymphoma mortality between 1973 and 1987 in the vicinity of nuclear power plants in Japan. Their study concluded that mortality from these diseases in the municipalities where the facilities were located was not significantly different from the control areas. The authors reached this conclusion by analyzing Standardized Mortality Ratios for each individual municipality. This created a multitude of small-number comparisons producing results of very low statistical power and guaranteeing that unless large numbers of illness were detected, no statistical significance would ever be derived from the study. The data was reanalyzed by Ziggel *et al*. (1996) by pooling the incidence of leukemia and lymphoma for all municipalities housing reactors and for the control regions. When this was done, it was discovered that in the period 1973-1987, there were 307 observed leukemia deaths in all age groups where only 251 would have been expected based on Japanese national figures. The resulting Standardized Mortality Ratio of 1.22 demonstrated a 20% increase in leukemia in the study areas.

The previous examples come from Europe and Asia, but health and longevity can be compromised just as easily by reactors operating within the United States. Evidence substantiating this was published in the *Archives of Environmental Health* in the article "Elevated Childhood Cancer Incidence Proximate to US Nuclear Power Plants." Mangano *et al*. compiled data on rates of cancer and leukemia in people living within a 30-mile radius of 14 commercial nuclear power plants located in the eastern United States. The 49 counties under investigation were home to approximately one-third of the 50 million Americans who live within 30 miles of a nuclear reactor. The rates of illness in the study area were then compared to rates compiled by the Surveillance, Epidemiology, and End Results Program (SEER) of the National Cancer Institute. SEER data is widely regarded as an accurate proxy for national incidence data. It compiles statistics from established tumor registries in five states and four metropolitan areas, representing about one-tenth of the US population.

In their study, Mangano *et al.* discovered that the incidence of total cancers in children under five years of age during the period 1988 to 1997 was higher near every one of the 14 nuclear plants than the national incidence rate represented by SEER data. The smallest excess in the cancer rate, + 0.7%, was observed near the Salem/Hope Creek nuclear facility in New Jersey. The largest excess, +29.1%, occurred near both the Turkey Point and St. Lucie power plants in Florida. The childhood cancer rate for all 49 counties

combined was 22.51 per 100,000. This was 11.4% greater than the SEER rate.

For the same period, cancer incidence in children between the ages of five and nine exceeded the SEER rate in 13 of the 14 areas under study. Cancer incidence was 12.15 per 100,000 — 12.5% higher than the SEER rate of 10.80. The smallest excess of +2.2% was found near the Millstone reactors in Connecticut. The largest excess, +73.6%, occurred near the St. Lucie reactors in Florida. (For the sake of comparison, the incidence rate near the Crystal River facility in Florida was 6.5% below the SEER rate.)

When the two age groups were combined, the rate of cancer incidence was calculated to be 17.42 per 100,000 children, which is 12.4% above the national rate found by SEER. In 38 of the 49 counties studied, cancer incidence rates in children from birth to nine years old exceeded the rate for the US as a whole. When the incidence of childhood cancer occurring in counties within 30 miles of the reactors under study were compared to the rates for the remaining counties in states where the reactors were located, cancer incidence was once again discovered to be higher. The total excess incidence between the two groups of counties was 5.0%.

Investigating the incidence of childhood leukemia, Mangano *et al*. examined the rate in the 23 counties near five nuclear power plants in Pennsylvania. These regions accounted for slightly more than half the population of the state. Leukemia in these counties exceeded the US rate by 10.8% while the remainder of the state showed an incidence that was 11.5% *below* the US rate. According to the authors: "This finding supports the considerable evidence that, although the risk of all forms of childhood cancer is increased by radiation exposure, the risk may be greatest for leukemia." For all other cancers, no difference was seen in the rate of incidence between the nuclear and non-nuclear counties even though they both exceeded the national rate by 2.6% and 3.2% respectively. The researchers concluded:

> This study found a consistent pattern of increased childhood cancer incidence in all study areas < 30 mi (48 km) from nuclear plants in the eastern United States. Our findings support the biologically plausible concept that susceptibility to carcinogens, such as radioactivity, is greatest in utero and in early childhood. They also support numerous analyses documenting elevated childhood cancer rates near nuclear facilities in the United States and other nations. The finding that cancer incidence for children < 10 yr. is 12.4% greater in the study counties than the US as a whole suggests that emissions from nuclear power plants may be linked with 1 of 9 local cases of childhood cancer. These descriptive epidemiological findings suggest a relationship

> between radioactive nuclides and childhood cancer and should be taken seriously in future research.

People tolerate nuclear power plants in their midst only because of constant reassurances by government and industry that routine emissions of radionuclides are insignificant and "doses" to the population are below regulatory concern. This posturing is intended to imply that the health of citizens is not being eroded by radiation. But what about the high incidence of breast cancer consistently found downwind of nuclear reactors?

"Libel!" thunders the Cult of Nuclearists. "Call in the prosecutor! The National Cancer Institute, in a study completed in 1990, found no heightened rates of cancer among populations living in proximity to nuclear reactors!"

The NCI study being referred to is *Cancer In Populations Living Near Nuclear Facilities*. If ever there was a scam orchestrated to beguile citizens, this was it. Thanks to Jay M. Gould and members of the Radiation and Public Health Project, its fraudulent conclusions were exposed in their book, *The Enemy Within: The High Cost of Living Near Nuclear Reactors*. As revealed in this work, the authors of the NCI research, in a brilliant act of deception, based their entire study on the devious premise that the only people exposed to radioactive emissions from nuclear power plants are the people living within the counties where the facilities are located. Swept under the carpet was the embarrassing little detail that liquid and gaseous effluents pay no attention to county lines, that they are whisked to outlying counties by meteorological and geophysical forces. By defining at-risk counties as those actually hosting the reactor, the NCI authors harvested a second boon for deceit. Most nuclear reactors are located in rural counties with relatively small populations. Consequently, an increased incidence of breast cancer mortality, if one were detected, would represent only a small number of cases, too small to be considered statistically significant. As observed by Gould,

> A change in mortality in any county cannot be considered significant if it can be shown to be the product of chance variation. Most of the 3,000-odd counties in the United States are small rural counties. Any single county would have to register an extremely high above average mortality increase to be judged statistically significant, simply because there would be too few deaths involved.

Thus, guaranteed by the dishonest methodology of examining cancer mortality in individual counties, the foregone conclusion was that no "statistically significant" rise in cancer mortality would ever be found among residents of "nuclear counties." The NCI

study echoed this in its conclusion: "if any excess cancer risk was present in the US counties with nuclear facilities, it was too small to be detected with the methods employed." Case closed! Nuclear reactors do not cause cancer.

The monumental deficiencies of the NCI study and its counterfeit claim that living nearby to nuclear reactors presented no hazard to health were first exposed by Joseph Mangano in his article "Cancer Mortality Near Oak Ridge, Tennessee." (Oak Ridge was one of the secret cities of the Manhattan Project, created during World War II to produce uranium-235 by the process of gaseous diffusion. After the war, it remained a major production facility, helping America to amass its nuclear arsenal.) When the NCI turned its attention to Oak Ridge, it confined its study to examining cancer mortality for the two counties in which the facility was actually located, Anderson and Rowe. Although it identified an increased rate of cancer mortality in these counties when compared to the nation as a whole, the excess cancer deaths did not represent a sufficient number of cases to be statistically significant.

Using a more sensible methodology, Mangano set out to reexamine any possible connection between cancer mortality (from all types of cancer) and the nuclear pollution emitted from Oak Ridge. He compiled NCI statistics of the aggregated age-adjusted cancer mortality rates from 1950-52 to 1987-89 for the 94 contiguous counties within a 100-mile radius of the Oak Ridge facility. Using this approach, he overcame the two shortcomings of the NCI study. His "nuclear counties" were more realistically representative of areas actually contaminated by radionuclides emanating from Oak Ridge, and the study population was large enough for statistical significance to be achieved. (During 1987-89, 20,000 cancer deaths were on record within the area studied.) What Mangano uncovered put the NCI research to shame. During the period under investigation, combined cancer mortality rates in the counties under investigation increased 34 percent as compared to the five percent increase for the United States as a whole. As Gould observes,

> The probability that so great a divergence over a 37-year period could be the result of chance is less than 1 in 10,000 cases. Proximity to the plant must be a factor involved in this epidemiological anomaly. In the absence of a plausible alternative explanation, it is evident that some malevolent force of mortality has been emanating from the Oak Ridge reactors for a long enough time to have a much wider geographic impact than would be shown by merely the two counties chosen by the NCI for study."

Through his new window on the cancer cluster near Oak Ridge, Mangano was also able to observe important environmental trends that had remained invisible in the NCI

study. For instance, he discovered a significantly greater combined cancer mortality risk for counties located downwind of Oak Ridge, to the north and northeast, in comparison with counties upwind of the facility. This was to be expected if the center of the study area, the Oak Ridge reactors, were responsible for the increased mortality rates. He also discovered that residents living in elevated mountain counties faced a greater risk of cancer mortality than people living in lowland counties due to the greater precipitation to which they were exposed. This also was to be expected since radionuclides afloat in the air are brought down to the ground primarily by rain and snow.

Replicating Mangano's methodology, Gould *et al.* studied age-adjusted breast cancer mortality in white females nationwide based upon a county-by-county database published by the NCI. Examining statistics for the 71 counties fully enclosed within a 100-mile radius of Oak Ridge, they calculated a *29* percent increase in aggregated breast cancer mortality during the same study period (1950-54 to 1980-84) compared with the national increase of only *one* percent. Recognizing that nuclear pollution from other distant sites may have contributed to the cancer increase in so large an area, the researchers narrowed their study to 20 contiguous rural counties downwind of Oak Ridge. In this instance, the aggregated breast cancer mortality rates showed a gain of *38* percent. In comparison, eight counties upwind of Oak Ridge during the same period had a four percent *decline* in breast cancer mortality.

The Enemy Within recounts the complete study performed by Gould *et al.* who investigated 60 reactor sites throughout the United States and calculated the age-adjusted breast cancer mortality rates within areas of 50- and 100-mile radii from these installations. What they uncovered was that, throughout the nation, counties within these designated areas had significantly higher rates of breast cancer mortality than either aggregates of counties further from reactor installations or for the nation as a whole. (The 50-mile radius was set for the study because the Nuclear Regulatory Commission uses a 50-mile definition to calculate dosages to the population in connection with nuclear plant licensing procedures. The implication is that the NRC is granting licenses to facilities that are killing women with dosages that are deemed safe.)

The national database used by both the NCI and Gould *et al.* consisted of 3,053 counties. In the research conducted by the NCI, cancer mortality rates around 62 reactor facilities were studied. On the basis of their location, only 107 counties were identified as "nuclear" counties, i.e., counties hosting or immediately adjacent to the reactors whose population was considered potentially exposed to radionuclides. This fundamental premise of the NCI study is completely unsound. Any eighth grader would know that pollution vented into the air or flushed into waterways will migrate great distances through the envi-

ronment, contaminating humans either directly or through food chains or water sources that in turn will be the vehicle for contaminating humans. The control population used by the NCI consisted of people living in 292 different counties. For three-quarters of the nuclear facilities under investigation, the control counties were *adjacent* to the nuclear counties. All the control counties were located within 100 miles of a reactor. This ridiculous choice hopelessly biased the data. Whatever exposure to radionuclides suffered by people in a "nuclear county" would likely be suffered by people dwelling in a "control county." Rates of cancer would be similar, allowing the fraudulent conclusion to be reached that people in nuclear counties are at no greater risk of dying of cancer than anyone else. This foolishness is an example of our tax dollars at work.

Gould *et al.* reviewed the conclusions of NCI study. When they looked at all 107 nuclear counties as an aggregate (simultaneously taking into account cancer rates in each county before and after the startup of each reactor), they observed a statistically significant increase in all types of cancer including breast cancer. When they combined the populations of the 107 nuclear counties with the 292 control counties and compared the cancer mortality rates in this population to the rates for the US as a whole, they once again discovered a statistically significant increase in cancer risk for this group of people. This finding soundly refuted the NCI claim that nuclear reactors were not inducing excess rates of cancer.

In their own study, Gould *et al.* studied 60 reactor sites and the age-adjusted breast cancer mortality rates in those counties located within a 50- and 100-mile radius of these facilities. This procedure produced study populations large enough to display statistical significance. At one point, using a methodology similar to that of the NCI, they calculated the combined breast cancer mortality trends of seven contiguous rural counties downwind and within 50 miles of each reactor. The total number of counties was 346. For the period 1950-54, the recorded age-adjusted breast cancer mortality rates for the people living within these counties was well below that of the US as a whole. In contrast, breast cancer mortality among women living within these counties today is well above the national rate. This observation again refutes the conclusions of the NCI study. As Gould observes in *The Enemy Within*:

> All in all, for 55 out of the 60 reactor sites we have been able to define some 346 contiguous, mainly rural counties that adjoin one or more reactor sites that have registered aggregated increases in current breast cancer mortality rates significantly higher that the corresponding national increase. Our sole purpose here is to demonstrate the

> limitations of the NCI definition of proximity to nuclear reactors, which in almost all cases resulted in too small a number of deaths to achieve statistical significance.

In the Gould *et al.* study, 1319 counties in the United States were identified as being "nuclear," within 100 miles of a nuclear reactor. The remaining 1734 counties, mostly rural and lying between the Rocky Mountains and the Mississippi River, were defined as "non-nuclear." For the period 1985-89, the combined age-adjusted breast cancer mortality rate for the nuclear counties was 25.8 deaths per 100,000. By contrast, the breast cancer death rate in the non-nuclear counties was 22.1 deaths per 100,000. Once again, the conclusion was reached that nuclear reactors were inducing cancer in the population. In an attempt to discredit this conclusion, the NCI undertook a review of the study of Gould *et al.*, copying their methodology. Looking at the mortality rate of nuclear counties within 50 miles of a reactor site, they estimated a rate of 26.9 breast cancer deaths per 100,000 women, based on the 69,554 deaths nationally in the years 1985-89. In contrast, the breast cancer death rate for all other counties was calculated at 23.3. Of this, Gould made the following observation:

> The probability that so great a difference could be due to chance is infinitesimal. This means that the cause of the current epidemic increase in breast cancer involves geographical factors that must be environmental and cannot be ascribed to differences due to genetic factors. We must therefore discard all the "blame the victim" and lifestyle factors invoked by the authorities to conceal the true man-made cause of the epidemic.

Following up on the idea that a woman's geographical location and the environmental forces acting within that location may be a factor in the development of breast cancer, Gould *et al.* compiled data for age-adjusted breast cancer mortality rates (age-adjustment to 1950 standard population) of white women for each of the continental 48 states and the District of Columbia. They compared the breast cancer mortality rates for the periods 1950-54, 1980-84 and 1985-89, and displayed this data in a chart where the states were organized into the nine census regions of the country. In this way, regional variations would be immediately apparent and possible environmental factors could be easily postulated. Shockingly, the NCI had never published national data in this format, ruling out a useful method for detecting environmental influences that may be contributing to cancer. This was either a gross oversight, or perhaps, another scam. Gould notes that only once did the NCI publish a table for breast cancer rates for all states, for the period 1984-1988, but the data was organized with the states listed alphabetically. This method precluded easy detection of regional, i.e., environmental, causes of cancer. When the statistics compiled by the

NCI were organized and displayed by regions, the end result supported the conclusion that a regional correlation existed between age-adjusted breast cancer mortality rates and cumulative release of radioactivity from weapon tests and commercial nuclear power plants. Fission products in the diet and drinking water — new pollutants introduced into the environment at the end of W.W.II — were identified as the likely initiators for the increasing rates of breast cancer. During the course of their research, Gould *et al.* made a host of interesting discoveries, some of which are listed below:

1. In the New England, Middle Atlantic, and East North Central regions, breast cancer mortality rates are significantly above the national average. Such widespread distribution of above-average rates in a genetically diversified population rules out the possibility that genetic factors alone are responsible. Some unidentified environmental factor is at work sustaining the breast cancer epidemic.

2. Breast cancer mortality rates in the Southern and Mountain regions have been rising since 1950-54 far more rapidly than in the nation as a whole. New Mexico and North Carolina registered increases as great as 30% since 1950 compared to moderate increases for the US as a whole of only 2% for 1980-84 and 1% for 1985-89.

3. For the period 1950-54, 10 years after the beginning of nuclear weapon testing, breast cancer mortality rates differed widely between regions. The lowest rates were in the rural East and West South Central regions. Arkansas had the lowest mortality rate of 15.4 deaths per 100,000. Again, differing rates of breast cancer in different geographical regions bear witness that genetic factors are not the sole cause of the breast cancer epidemic.

4. In the period between 1950-54 and 1980-84, the state with the greatest increase in breast cancer mortality was New Mexico, with the rate increasing by 39%. Why New Mexico? Could the Trinity nuclear weapon test in 1945 and the presence of the Los Alamos nuclear laboratory be possible contributing factors? Supporting this contention is the fact that in the 10 contiguous counties in the southeast corner of New Mexico, the region in which the Trinity blast occurred, combined age-adjusted mortality rates increased by 72%. In 1950-54, there were 12.1 deaths per 100,000 people. By 1980-84, 40 years after the test blast, the rate had increased to 20.9 per 100,000.

5. After New Mexico, Arizona and Utah showed the next greatest increase in breast cancer mortality — 29%. These states, bordering Nevada and immediately downwind of the Nevada Test Site, were the routine dumping ground of large amounts of radioactive fallout from weapon tests that silently and invisibly contaminated food and water sources.

6. The cessation of aboveground weapon testing in the early 1960s had a marked influence on breast cancer mortality rates 20 years later. Not only did the enormous increase in breast cancer mortality taper off within the rural states of the Mountain region bordering the Nevada Test Site, they actually showed a significant decline between 1980-84 and 1985-89. This reversal is no surprise if fallout contamination in the diet was a contributing factor to cancer rates.

7. Of the nine census regions, the West South Central region, comprised of Arkansas, Louisiana, Texas and Oklahoma, had the lowest rate of breast cancer mortality for the entire period between 1950 and 1989. These low rates persisted despite the fact that these states hosted the largest petrochemical manufacturing facilities in the nation and their agricultural lands were the repository for large amounts of DDT and other chlorine-based pesticides and herbicides. Consequently, these environmental factors by themselves cannot be responsible for the breast cancer epidemic. If they are in some way responsible, some other unidentified cofactor(s) must also be involved.

8. In contrast to the declining rates of breast cancer in the Mountain region after the end of aboveground weapon testing, breast cancer rates continued to climb between 1980-84 to 1985-89 in the rural southern states along the east coast from Delaware to Florida. If nuclear pollution is contributing to the breast cancer epidemic, this fact can be explained by the ongoing emissions of radiation from the region's commercial nuclear reactors and releases from Oak Ridge and the nuclear weapon installation at Savannah River. All but one of the nine southern states along the Atlantic coast with nuclear reactors registered increases in mortality rates. In contrast, this was not the case in the high rainfall states of Louisiana, Kentucky, and Mississippi, which had no operating reactors before 1982. These states registered declines in breast cancer mortality of three, six, and three percent respectively during the 1980s.

9. Despite the cessation of aboveground weapon testing, breast cancer mortality continued to climb in states receiving large amounts of radioactive pollution from nuclear facilities. This was particularly evident in Rhode Island, downwind of four large reactors in Connecticut and two smaller reactors at Brookhaven National Laboratory in Upton, New York. Rhode Island, during the 1980s, had the largest increase of any state in breast cancer mortality.

10. Identifiable trends in the rates of breast cancer mortality exist between different states that are explainable on the basis of varying levels of radioactive pollution. For instance, almost every rural state showed increases between the period 1950-54 to 1980-84, most probably as the result of fallout from weapon tests. In the period between 1980-84

and 1985-89, a different pattern emerged. In states with no operating nuclear reactors, the rate of breast cancer deaths began to decline whereas in states most significantly exposed to emissions from nuclear reactors, rates continued to climb. The rural states evidencing declines in breast cancer mortality included North and South Dakota, Kansas, West Virginia, Kentucky, Louisiana, Oklahoma, Texas, Montana, Wyoming, Colorado, New Mexico, Arizona, Utah, and Nevada. As observed by Gould: "Since all of these rural states had similar exposures to pesticides and other chemical pollutants, we may conclude that exposure to bomb-test radiation was the principal cause of the overall increased mortality since 50-54."

11. Between the period 1950-54 and 1985-89, breast cancer mortality in the Washington state county housing the Hanford Reservation increased from 13.2 to 21.7 deaths per 100,000. For the county in which the Idaho National Engineering Laboratory was located, rates increased from 4.8 to 21.7. In St. Lucie county in Florida, exposed to pollution from four commercial nuclear reactors, the death rate from breast cancer jumped from 6.5 to 23.5.

12. In the 14 counties in which the seven oldest DOE reactor sites are located, combined age-adjusted breast cancer mortality rates for white females rose by 37 percent during the period 1950-54 to 1985-89. During the same period, the corresponding rate in the US as a whole rose by only one percent. In these 14 counties, the rate quintupled, from 371 deaths to 1,926 deaths, while the rate in the US as a whole only doubled.

13. The Oak Ridge study can be replicated for any area in the country where old DOE facilities are located. Women living in counties near the oldest reactor sites have registered by far the highest long-term increase in breast cancer mortality of women in any group of counties in the nation.

14. A comparison was made of breast cancer mortality rates among women in an aggregate of 14 counties that housed seven DOE facilities with reactors to women in an aggregate of nine counties housing DOE facilities without reactors. The women living in the 14 counties exposed to reactor emissions displayed an extraordinary and significant increase in breast cancer mortality of 37% between 1950-54 to 1985-89, compared to a 6% decline among women living in the counties not receiving emissions. This is a clear demonstration that reactor emissions are producing breast cancer.

15. The flat low-rainfall states between the Rocky Mountains and the Mississippi River receive the lowest exposure to fallout from commercial nuclear reactors and have the lowest rates of breast cancer mortality.

16. Most civilian nuclear power plants are located in areas where precipitation levels are over 30 inches per year. There are only five reactors located in states with annual levels of precipitation below 15 inches. Interestingly, these five reactor sites are the only ones studied that fail to show a significant upward divergence in breast cancer mortality rates compared to the nation as a whole.

17. Brookhaven National Laboratory is located in Suffolk county in New York state. From 1950-54, when BNL began operation, through 1985-89, the county's rate of breast cancer mortality was 40 times greater than the increase throughout the nation as a whole.

The research accumulating on the health detriment produced by released radioisotopes is putting the Cult of Nuclearists in a terrible double-bind. Mounting pressure will eventually force them into admitting either that doses to exposed populations have been greater than previously published or that the risk factors are in substantial error. They cannot have both. The only escape from this predicament is to attack the integrity of the research that casts them into this dilemma. This tactic, however, is becoming increasingly transparent as evidence mounts that radioisotopes in the environment are producing illness and death.

To complete this indictment, we must return to the subject of depleted uranium weaponry. Research, to be discussed in later chapters, has confirmed that veterans suffering symptoms of what is called Gulf War Illness test positive for the presence of depleted uranium in their bodies. These findings must be taken seriously. But those who defend depleted uranium munitions as radiologically benign don't sponsor credible research to confirm their claims. Instead, they rely on two arguments to bolster their position. First, the *dose* of radiation delivered by internalized uranium is too low to produce injury; second, a review of published studies on internal exposure to uranium provides no evidence that DU, in concentrations likely to be encountered on the battlefield, could be radiologically hazardous. Setting aside the second argument for a later chapter, the first argument can now be easily refuted. The concept of dose falls apart when applied to low levels of internal contamination with radioactive particles. It is a meaningless and scientifically fraudulent idea when transported from the phenomenon of external exposure at high doses of x-rays and gamma rays and then forced to fit the altogether different phenomenon of localized damage to cell clusters vastly smaller than whole organs. The rationale of this translation is that both phenomena share the common characteristic of transferring energy from the radioactive source to tissue. However, dose requires averaging energy over masses of tissue, and it is scientifically absurd to take localized emissions from embedded radioactive particles and average that energy over the mass of an entire organ. All this does is make the biological damage disappear behind some mathematical hocus-pocus, which then pro-

duces the impression that the contamination and the cellular chaos it causes are irrelevant. Radioactive particles decaying within the human body cause biomolecular alterations and cellular damage. The important scientific question is whether this damage is repaired or if it induces altered function and disease. "Dose" provides no relevant information on this fundamental issue. It is just a mathematical abstraction that is adequate for quantifying whole-body exposure or whole-organ exposure to either x-rays/gamma rays or a uniform distribution of a radionuclide throughout an organ, but it is meaningless when applied to nonuniform distribution of radioactive particles. Further, the Hiroshima study and other studies of external exposure provide no relevant information regarding low levels of exposure to internally embedded hot-particles. Again, the notion that it is scientifically justifiable to extrapolate from high levels of external exposure to low levels of internal exposure is grounded on the erroneous idea that biological effect is proportional to the quantity of energy absorbed. However, as has been shown, the alteration of essential macromolecules within cells has nothing to do with the quantity of energy absorbed. It is voodoo science to discount the hazard of embedded uranium particles, or any other radioisotopes, solely on the basis of dosage. The only responsible way to proceed for determining whether or not contamination by depleted uranium is hazardous is to examine the outcome of epidemiological studies of instances of uranium exposure and determine the health consequences. The question to be addressed later is whether or not any previous studies have any relevance to the inhalation on the battlefield of insoluble, micron-sized particles of alloys of uranium metal laced with other contaminants such as plutonium, americium, neptunium, and technetium-99.

SUMMATION

On the landscape of human affairs, the Cult of Nuclearists are deceivers. Members of this syndicate confound the world with their magnificently orchestrated stagecraft, but in the wake of their theatrics, the fruits of their deeds have left indelible signs of their intentions. Can humanity entrust its common welfare to a pack of liars? Are people to be trusted who harbor a mentality for harnessing the fundamental forces of the universe for the purpose of committing acts of genocide? Is it prudent to expect beneficence from those who poison the biosphere with radionuclides that never before existed on the Earth's surface and then artfully lie to cover up the implications of their misdeeds? What kind of people are these? What is their ultimate agenda? With abundant evidence of their mentality, is it prudent for us to allow them further management of human affairs?

Karl Morgan was the father of health physics and the chairman of Subcommittee Two, which set the first standards of safety for fission-produced internal emitters. During the Allen trial in the early 1980s, when downwinders of the Nevada Test Site unsuccessfully

sought compensation from the US government for radiation induced illnesses, Morgan made the following observation:

> We have radiation with us, we've always had some radiation with us, and it's an added risk. The people deserve to know what the risk is, and they should make the decision on how much radiation they want to take or are willing to take, and there shouldn't be any cover-ups. There shouldn't be any withholding of information. The people themselves should decide on their own future and the future of their families (Fradkin).

Rather than allow the people this choice, the Cult of Nuclearists defrauded the entire human race in order to fulfill their still unstated agenda. Why? In fabricating the ultimate weapon, those who thirst for dominance fulfilled their crowning achievement. But they were left having to explain away one bothersome little side effect: nuclear radiation dissolves human molecular structure. From the moment the smoke cleared over Hiroshima, disparaging rumors began circulating around the globe of an atomic plague that infected all who managed to survive the bomb's initial decimation. To preserve their good name, the Cult of Nuclearists mounted a campaign of deceit to distract the minds of inquiring humanity. At times they went to ridiculous lengths. General Leslie Groves had the audacity to testify before Congress that death by radiation was a pleasant way to die! This campaign of misrepresentation has continued nonstop since 1945. As absurd as it will sound to future generations, it has been eminently successful. Through craft, the Cult of Nuclearists has pushed back every challenge to its self-proclaimed right to build and test its arsenal of conflagration, all the while contaminating the Earth and robbing the lives of unsuspecting innocents. It withstood the numerous waves of worldwide protest staged by anti-nuclear activists. It covered up the plight of sickened populations such as the downwinders and the Marshallese Islanders. It successfully postponed, indefinitely, a call for a solution to the problem of disposing of nuclear waste. It rebuffed the claims of liability for illnesses incurred by atomic vets, vets contaminated by depleted uranium, nuclear workers, uranium miners, and residents living in proximity to weapon production facilities. The brilliant propaganda matrix it walled itself behind was vulnerable by just one inroad: science. When researchers, beginning in the late 1950s, began to publish projections of a future cancer epidemic induced by fallout, followed in later years by studies of the link between low-level radiation and infant mortality, thyroid disease and cancer, the Cult of Nuclearists flinched. Their self-assumed supremacy was threatened by possible future revelations of the medical effects of contamination by low-levels of radionuclides that they had vented into the environment. To permanently protect themselves from this Achilles heel, their devotees infiltrated the science of radiation effects and the radiation protection community.

By stealth, they promoted ideas and policies that gave license to the nuclear intrigues of government, rather than the other way around, with government forced to constrain its activities within stringent guidelines designed to protect the health and welfare of the governed. The archaic, devious and deadly system in place today that is supposed to be protecting humanity from the hazards of radiation is the fruit of this mischief and contains within itself abundant proof of intentional malfeasance.

Exhibits A through F provide copious evidence that the science of radiation effects, as currently construed, harbors fundamental errors. While biology has been completely transformed since the 1950s, the radiation protection community insists on clinging to an outdated model to explain how internal contamination by radionuclides affects living systems. Had it been in any other discipline, this antiquated model would have been junked long ago. The reason it has remained entrenched and is continually fortified by new layers of deceit is that it serves the strategic role of disguising crimes against humanity as perpetrated by the nuclear powers and much of the nuclear industry. The corrupted science has helped to sanitize the immense evil that lurks in the shadows of our modern life. The possessors of nuclear weapons have reserved for themselves the capacity to annihilate any population of their choosing, at any moment of their choosing. People of today have erected a facade of normality around this harrowing fact where the fairytale of benign radiation fits perfectly in place. The masquerade we are forced to assume to retain our sanity disguises the ruthless brutality that encompasses us. Our seemingly secure lives are but a single moment away from cataclysmic annihilation.

Albert Einstein once said: "The splitting of the atom has changed everything save our mode of thinking, and thus we drift towards unparalleled catastrophe." Some Manhattan Project scientists recognized this in the course of their work. Once Germany surrendered, they began to question the need for fielding an atomic bomb as the war wound down. They recognized that the bomb was going to produce a crisis in governance, that a world divided into autonomous nation-states possessing nuclear weaponry would eventually self-destruct. Many lobbied for the new weapon to be put under international control. Some fantasized that a world government, more humanitarian and less insidious than the New World Order of today that is conniving toward world domination, would be the only safeguard from self-annihiliation. But the old mentality was not dislodged by the advancement in weaponry, and it accommodated itself to a world of nuclear confrontation.

The Cult of Nuclearists is a confederation of like-minded individuals. What binds them together is their shared mentality. They premeditate genocide and call it national defense. They retain their hold on power by threatening ruthless force of unlimited constraint. Their manifesto perpetuates the ideology that nuclear weapons are beneficent, that

threatening extermination ensures the peace, that those with their finger on the button are our caretakers. They consume the wealth of the people of the Earth with trillions of dollars in armaments spending. They inflict heart-gripping terrorism on every human being alive. While the rest of us wile away our days in sanity-preserving somnambulance, the Cult of Nuclearists builds, meditates, plans.

Until today, the Cult of Nuclearists has escaped accountability for its deeds. Rather than wait for Armageddon to unmask these liars and the hidden intentions that lurk within their hearts, the trial within these pages has been convened to give humanity a chance to ward off catastrophe. With the evidence of Exhibits A through F now before the jury, one last question needs to be addressed. Why is the Cult of Nuclearists not being brought to trial for murder? Why fraud? The answer to this question ultimately leads to an indictment of us all for our complacency. Beyond debate, the bombings of Hiroshima and Nagasaki were merciless crimes of wholesale slaughter. What followed, during the era of atmospheric weapon testing, was a dusting of the Earth with nuclear pollution that has induced millions of fatal cancers. A repetition of this atrocity is underway with the first fielding of radiological weapons. These deeds should be sufficient to earn a murder conviction for their perpetrators. But the Cult of Nuclearists has escaped accountability. And with their freedom, they have gone on to devise the means for further crimes against humanity yet to be enacted. By some quirk in the make-up of modern human beings, the crass materialism and barbarity of the twentieth century has deadened our consciences. Extreme brutality and mass murder has left us jaded. Moral outrage about the transformation of our world by nuclear weapons has never crystallized. Like a deer caught in the headlights, the entire human species has been intimidated into inaction by hellish displays of mushroom clouds and terror for the future of our children. We accept the possibility for our species of self-immolation, believing this to be an innate expression of the darkness lurking within the human heart rather than the connivance of a bunch of gangsters. The Cult of Nuclearists has gotten away with murder, for the will to confront and condemn them has never coalesced.

If any hope remains for our outrage to be inflamed, it lies in the personal recognition within each human heart that the lies we have been tutored in has done violence to our own humanity. By deceit, we have been transformed into submissive allies in the war being waged against nature and against life. Having been robbed of the ability to recognize evil and take a stand against it, our own personal integrity has been compromised to make way for criminals to rule the Earth. As bitter a remedy as it is, courage is demanded for each one of us to finally acknowledge that we have been conned into forsaking our own safety, the welfare of our children, the future of our planet, the endless possibilities of our species.

The Most Heinous Crime in History

If a nuclear holocaust ever engulfs the earth, those who crawl out from the rubble, and their descendants, will hunger to know what happened. Around the campfire, they will enchant each others with marvelous tales of their forebears: of our ability to fly through the air, to instantaneously talk to anyone else on Earth, to miraculously harvest whole fields in a single day without effort. They will scratch their heads in bewilderment at how a whole generation of humans, given so much, sacrificed it all in a senseless act of self-destruction. They may never know that this inglorious end was facilitated by deceit and treachery. But they will feel our humiliation, and this will be part of the oral tradition that will pass down from generation to generation. Our dishonor will be the dishonor of all human beings that follow. Our tragedy and shame will be the legacy our complacency bequeaths to the future.

7

The Chicanery of the REAC/TS Radiation Accident Registry

If you tell a lie big enough and keep repeating it, people will eventually come to believe it. The lie can be maintained only for such time as the State can shield the people from the political, economic and/or military consequences of the lie. It thus becomes vitally important for the State to use all of its powers to repress dissent, for the truth is the mortal enemy of the lie, and thus by extension, the truth is the greatest enemy of the State.

Joseph Goebbels, NAZI Propaganda Minister

Human beings delight in being deceived. By some oddity of mind, we are entertained and experience delight in being confounded by events that defy our perceptions, our expectations, and our logic. This accounts for the popularity of magic shows. A rabbit being pulled out of an empty hat, an elephant made to disappear before our eyes, a beautiful woman being sawn in half with no obvious signs of hurt: these fantastic feats mesmerize us. We love the magician's sleight of hand, to be drawn into the show and have the wool pulled over our eyes. We'll pay good money for this amusement and will gladly lay down more to be beguiled yet again.

Those most sophisticated in the art of deception, with something truly heinous to conceal, play on this human quirk and turn it to their advantage. Rather than entrust locked doors, which can be breached, to preserve their secrets, they cache them in the light of day and invite everyone in to examine them. They practice their clandestine deeds in

plain sight. They use the absence of disguise as the most effective camouflage. They are the ones who arrive at the masquerade ball dressed in their street clothes. Their candor and forthrightness are their stealth. With something as truly dangerous as ionizing radiation awash in the environment, they craft an impenetrable artifice, hypnotic and bewitching, that persuades the world that this radioactivity is innocuous and benign.

There is no more accurate way than this to characterize the purpose of the REAC/TS Radiation Accident Registry. This central registry is championed as the preeminent source of information on the history of radiation accidents. At heart, however, the REAC/TS registry is a sophisticated, state-sponsored ruse, meticulously constructed so as to mislead the public into believing that the management of ionizing radiation by the nuclear establishment is without hazard and that few people fall victim to radiation injury. It is a front designed to instill false confidence in an enterprise that is both reckless and injurious. So beguiling is the structure of the Registry that even seasoned professionals in the radiation sciences fail to recognize the gimmicks that prop up its unearned legitimacy.

REAC/TS is an acronym for Radiation Emergency Assistance Center/Training Site. Established in 1975, it is operated by the Oak Ridge Institute for Science and Education in Oak Ridge, Tennessee for the US Department of Energy. (It is pertinent to recall that Oak Ridge grew up overnight as one of the secret cities of the Manhattan Project and continued after the Second World War to be a cornerstone of the nation's nuclear weapons program.) The REAC/TS facility has appointed itself the voice of authority on radiation accidents. A recent article succinctly summarized the function of REAC/TS:

> The REAC/TS program provides 24-hour direct or consultative assistance regarding medical and health physics problems associated with radiation accidents in local, national and international incidents. The REAC/TS facility serves not only as a treatment facility, but also as a central training and demonstration unit where US and foreign medical, nursing, paramedical, and health physics personnel receive intense training in medical management of radiation accidents.
>
> One of the objectives of the REAC/TS program has been to broaden knowledge of the early and late effects of radiation injury in humans, with the goal of developing better diagnostic, therapeutic and prognostic modalities. REAC/TS maintains registries to further this aim through preservation of valuable historical and medical records for use in research and medical and health physics training (Ricks 2000).

The central radiation accident registry maintained at REAC/TS is promoted as containing records of "***all*** *events that involve the known or suspected exposure of human beings to ionizing radiation* [emphasis added]" (Fry). As of December 31, 1999, the REAC/TS Central Registry had collected information on 1,792 events involving 142,624 individuals.

Once REAC/TS collects information about a radiation event in its Central Registry, the data is then channeled into one of five satellite registries.

1. The DTPA Registry maintains information on victims who were accidentally contaminated internally by actinides[1] and then given the drug DTPA on an experimental basis. DTPA is a chelating agent that assists in the removal of transuranic radioisotopes from the body. Six hundred and twenty-two individuals treated at 70 sites were included in this registry at the end of 1999.

2. The *Department of Energy (DOE)-Study Registry* includes records from the Central Registry of persons employed at government facilities who received in a single event a dose of radiation equal to or greater than 0.05 Sievert (5 rem). On record in this registry were 3,146 persons who were involved in 44 separate events. Although comprised of a small population, long-term epidemiological studies on health and mortality are underway on these individuals.

3. The *Non-US Radiation Accident Registry*, previously called the Foreign Registry, contains information on radiation accidents occurring outside the United States. In 2000, this registry had on record 169 accidents involving approximately 132,391 persons (Ricks 2001). Five major accidents account for the majority of this population. The disastrous meltdown of the Chernobyl nuclear reactor in 1986 is listed as having created 116,500 victims. The explosion of a waste storage tank at Kyshtym in Russia in 1957, an accident which scattered radioactivity into the surrounding countryside, accounts for 10,180 victims. Four thousand people were exposed to gamma irradiation in 1983 in Juarez, Mexico. In that accident three thieves broke into a warehouse and stole the radiation source from a cancer therapy machine. Prying open the unit, they liberated 6,000 pinhead-sized pellets of cobalt-60. These were either dispersed along the streets of Juarez or mixed with scrap metal which was later melted down and fabricated into 550 tons of concrete-reinforcing rods and 17,000 table supports. A similar accident occurred in 1987 in Goiania, Brazil, when thieves pillaged the radiation source from a medical teletherapy machine, broke open the canister, and liberated to the environment 1,375 curies of cesium-137. In this instance, four people died and 245 people received either external irradiation or internal contamination. A fifth major accident occurred in 1990 in Zaragoza, Spain, involving 27 people. Due to machine malfunction and operator error, radiation therapy patients received a more

focused beam of radiation than planned, with deeper penetration. Fifteen patients died, mostly from injury to their lungs or spinal cord, and 12 more suffered major disabilities. When the results of these five accidents are subtracted from the total cases listed in the Non-US Radiation Accident Registry, what remains on record is 164 separate events that resulted in radiation exposure to 1,435 individuals.

4. The *United States Radiation Accident Registry* contains information on radiation accidents that occurred within the United States between 1945 and 2000. By current convention, a distinction is made between a radiation "accident" and a radiation "incident." Unintentional human exposure to ionizing radiation is recorded as an "accident" and included within the United States Radiation Accident Registry only when certain minimum dose criteria have been met. Below these threshold doses, any exposed person is considered to have been involved in a radiation "incident" and is not included in the Registry. To be classified as a victim of a radiation accident, the victim must be ascertained to have received "significant exposure." According to those who maintain the Registry, "significant 'accidental ionizing radiation exposures' are defined as levels at which early biological changes and clinical symptoms might be detected" (Ricks 2000). Designation as a significant exposure requires the following conditions and dose criteria:

a. a dose of at least 250 mSv (25,000 mrem, i.e., 25 rem) to the bone marrow of the whole body, or to the gonads,
b. a dose to the skin of the extremities of 6,000 mSv (600,000 mrem, i.e., 600 rem),
c. a dose to organs such as the eye or thyroid of 750 mSv (75,000 mrem, i.e., 75 rem),
d. internal contamination by radionuclides at levels exceeding 1/2 the maximum permissible body burden as recognized by the National Council of Radiation Protection,
e. medical misadministration of radiation at doses meeting any one or more of the above criteria (Ricks 2000).

According to the statistics maintained by REAC/TS, during the period of 1945 to 2000, 246 events occurred in the United States that were classified as radiation accidents. The number of people "involved" in these events, who received any radiation exposure at all, totaled 1,352. The actual number of these people who received dosages meeting the dose criteria and who are included in the US Radiation Accident Registry is 790. As a disclaimer, the following observation is made: "There is good reason to believe this number does not represent all radiation accidents in the US. Some accidents are unreported because of legal or financial concerns, lack of knowledge of radiation hazards or radiation effects, or because unsuspecting persons were unaware of an exposure" (Ricks 2000).

5. The *Zero Doses/Non-Accident Registry* is a catch-all category for events reported to REAC/TS that involved little or no actual exposure as determined by historical accounts, diagnostic testing, and/or dose estimation of the event. In these events, the people involved did not receive sufficient radiation to meet the dose criteria of the US Radiation Accident Registry. Records of these events are maintained, but these events are designated as radiation "incidents."

According to REAC/TS, only 30 people have ever died from the radiation they received in an accident. The greatest number of accidents, 161, were caused by radiation devices: "sources used in industrial radiography, radiotherapy, and industrial processes, x-ray generating devices used in medicine, research and industrial processes and quality assurance, and accelerators used in medicine and research" (Ricks 2000). In these types of accidents, 930 people were involved and 653 received significant exposure. The greatest number of accidental deaths and significant exposures occurred in 80 accidents that took place in medical facilities during diagnostic or therapeutic procedures. One accident alone was responsible for 403 of the total of 790 individuals that ever received significant exposure in the United States. Seven accidents occurred with X-ray devices, significantly exposing 12 individuals. There were 30 accidents in medical facilities using sealed sources of radioactive material. In these events, 617 individuals were involved, 457 of these received significant exposure, and 11 died. The use of radiopharmaceuticals created 38 accidents involving 112 individuals. Of these, 46 had significant exposure and eight died. Five accidents occurred during the use of accelerators in radiation therapy which caused three deaths and two serious injuries. As described:

> These accidents in hospitals and other medical facilities occurred because of classical errors: wrong patient, wrong dosage (for example, mistaking "milli" for "micro"), wrong medication or because of irradiation of the wrong area of the body. Other errors resulting in injury or death included failure to determine if a female was pregnant or nursing, incorrect calibration of therapy devices, incorrect computer programming, errors in equipment maintenance or repair, negligence, and malpractice (Ricks 2000).

According to the Registry, the most common type of radiation injury in the United States has been local injury to some part of the body. Seventy-five percent of local injuries are injuries to fingers and hands. Another six percent involve injuries to arms, legs, and feet. Nine percent of local injuries involve the head and neck. The remainder are to the thorax and other areas. These local injuries were caused predominantly by iridium-192 and cobalt-60.

Accidents resulting in significant exposure due to radionuclides deposited inside victims' bodies occurred in research and development activities, in industry, and most often, in medical facilities. In total, there were 71 such accidents involving 265 individuals of which 96 received significant exposure. There were 43 people who received significant exposure after being given iodine-131 or iodine-125 internally for medical procedures. In addition, "other radionuclides implicated in injuries and deaths include yttrium-99, plutonium and americium compounds, phosphorus-32, uranium compounds, gold-198, strontium-85, and mixed fission products" (Ricks 2000).

This, in a nutshell, is the US Radiation Accident Registry. It paints an idyllic picture of the first 55 years of the nuclear age. The phantasm it contrives is a world in which ionizing radiation is benign. There, biology is immune to the overwhelming energies of the nucleus that, in reality, shatter biologically significant molecules and disrupt the chemical processes upon which all life depends. In this dream landscape, the detonation of some 1,750 nuclear weapons worldwide have had no negative biological effects. The routine spewing of radioisotopes from commercial and military reactors and the nation's weapons labs has posed no dangers for the people dwelling downwind. The contamination of the waters and the lands and the air with unimaginable quantities of radioactive waste has been nothing less than the epitome of stewardship for our planet. And the weapons that contaminate the battlefields with depleted uranium have contaminated no one. It is only in this hallucinatory vision that representatives of the US Radiation Accident Registry can shamelessly proclaim: **"Serious injury due to ionizing radiation is a rare occurrence. The safety record, unmatched by other technologies, is due in large part to careful regulation and control provided by regulatory agencies and radiation protection specialists (medical and health physics professionals)"** [emphasis added] (Ricks 2000).

When one consults the US Radiation Accident Registry, one comes away with the impression that ionizing radiation is not a significant hazard. In 55 years, only 30 deaths were caused by radiation! Only 790 people received "significant" exposure! Compared to other industrial hazards and avenues of pollution, ionizing radiation is of no fundamental consequence to our well-being as a species or to the life-sustaining capacity of the Earth. If we are to believe the Registry's statistics, risk from ionizing radiation exists only in certain industrial settings and in medical facilities, where in the process of trying to save lives, mistakes are made. The Department of Energy needs to be lauded for supporting such scientific work of the highest caliber, performed with integrity, to calm the qualms of a misinformed populace.

There is only one little problem.

The US Radiation Accident Registry is a crock of excrement. It is a monument to the lies that have had to be told by the Cult of Nuclearists to coerce two generations of human beings into accepting the most hazardous enterprise and the most terrifying of weapons ever unleashed upon the face of the Earth by human beings. Such blatant falsehood is unconscionable. It is criminal and immoral. Its presence in the landscape of ideas is to lull the people of the United States to sleep while those who are enchanted by destruction of all that the rest of us hold dear devise ever more horrific means of decimation.

Let the court of public opinion convene to judge the veracity of the US Radiation Accident Registry.

Over the last half-century, a number of studies have been published attempting to gauge the impact to human health of the radioactive fallout from the aboveground testing of nuclear weapons that took place mostly during the 1950s and 1960s. The most recent study was published in 1997 by the National Cancer Institute. It concluded that, as a consequence of radioactive fallout from worldwide testing, as many as 80,000 Americans may have contracted radiation-induced cancers. Of these, 15,000 were probably fatal (Institute of Medicine, National Cancer Institute). The National Cancer Institute also performed dose reconstruction from fallout to the population of the United States from detonations at the Nevada Test Site. When the fissioning of uranium or plutonium takes place, the nuclei can split in about 40 different ways creating 80 different kinds of fragments. These decay at differing rates along individual decay sequences, creating a mixture of 400 isotopes isotopes (Gladstone). It is currently beyond human calculation to model the impact of this smorgasbord of radioactive contaminants, each with its own biological impact, and when working with others in concert, acting in unknown ways. Consequently, the National Cancer Institute study decided to focus on the health impact of just ONE of these radionuclides, iodine-131, which is readily transferred to human beings through the food chain and is selectively absorbed by the thyroid gland, creating easily diagnosed thyroid abnormalities. It was estimated that weapon testing in the continental United States scattered 150 million curies of iodine-131 over the population in doses large enough to produce between 10,000 and 75,000 cases of thyroid cancer, with 10 percent of these being fatal (National Cancer Institute, Schwartz).

Similar types of calculations have been performed by other organizations. The ICRP has attempted to calculate the number of deaths worldwide since 1945 that have resulted from humankind's nuclear experiment. Using models and figures for doses to populations through 1989 as supplied by the United Nations, the ICRP estimates that 1,173,600 deaths from cancer were induced by releases of radioactivity into the environ-

ment. The total number of cancers, fatal plus nonfatal, was estimated at 2,350,000. In contrast to this figure, the European Committee on Radiation Risk, using entirely different models, puts the death toll much higher. According to the 2003 recommendations of the European Committee on Radiation Risk: "The ECRR model predicts 61,600,000 deaths from cancer [total cancers estimated at 123,200,000], 1,600,000 infant deaths and 1,900,000 fetal deaths. In addition, the ECRR predicts a 10% loss of life quality integrated over all diseases and conditions in those who were exposed over the period of global weapons fallout" (ECRR). Infant deaths, fetal deaths, and loss of quality of life were not even given consideration by the ICRP.

Are any of these thousands or millions of cancers and radiation-induced deaths included in the US Radiation Accident Registry? NO!

Why not?

In the process of answering this question, the facade of the Registry begins to crumble.

By the rules of the game, a person is acknowledged as a victim of a radiation accident and included in the Registry only if he is identified and his dosage meets the dose criteria for inclusion. In environmental releases of radioactivity, the collection of this data almost never occurs. The victims who dwell in hotspots or take in over time biologically significant quantities of radionuclides in the air they breathe, the food they eat, and the water they drink, go unidentified. They remain unidentified because no one is testing them for their bodily burdens of radiocontaminants. If you do not look, you do not find. Further, because radiation-induced pathologies often take decades after exposure to manifest themselves, there is no method currently available to trace definitively the origin of an illness back to the event that unleashed radiation into the environment. To counter the complexity of measuring the radiation dose of every member of a population in order to assess the impact to health of environmental releases of ionizing radiation, researchers often resort to epidemiological studies of smaller target populations. However, the stipulation by the US Radiation Accident Registry that victims be identified on the basis of certain threshold dosages renders the science of epidemiology impotent and its assessments meaningless. The victims of radiation releases as calculated by epidemiological studies don't exist in the eyes of the Registry. These faceless individuals are overlooked as victims of radiation accidents. They are banished to oblivion. In the "real" world, only 30 people in the United States have died from ionizing radiation since 1944.

The US Radiation Accident Registry similarly banishes to oblivion malignancies

and deaths caused by commercial nuclear power plants. To cite just one of a myriad of possible examples, a study published in 2001 by the Radiation and Public Health Project disclosed statistics that put the Registry to shame. Research was conducted in the environs of four nuclear reactors in southeastern Florida: Turkey Point 3 and 4 and St. Lucie 1 and 2. During the period 1983 -1984, the first two years that the St. Lucie reactor operated, infant deaths in St. Lucie County rose 35.3%. Analysis of infant mortalities revealed rising concentrations of radioactive strontium-90 in children from the early 1980s onwards. Baby teeth acquired from the counties of Dade, Broward, Martin, Palm Beach, and St. Lucie showed levels of strontium-90 higher than anywhere else in the United States. In addition to this contamination, the area has rates of childhood cancer that are considerably higher than the national average. From the early 1980s to the early 1990s, the incidence of cancer in children under the age of 10 rose 35.2% in the counties studied compared to an increase of only 10.8% nationally. During the same period, childhood cancer in St. Lucie County increased by 325.3% which increased the cancer rate in the study area to more than double the national average. Although incidence of breast cancer mortality increased by only 1% nationwide since the 1950s, the incidence near Turkey Point and St. Lucie rose 26% and 55% respectively. Also, in the 1990s, the death rate from cancer among young adults in the age group 15 - 34 had risen in contrast to a national decline. Increases were particularly significant for breast, bone and blood cancers.

Again, will any mention of such victimization by radiation appear in the US Radiation Accident Registry?

No!

The Registry is structured in such a way as to be blind to the suffering of such innocent victims who sicken and die without ever becoming aware of the reason why. As in all cases of radioactivity dispersed into the environment, individual victims remain unidentified. Dosages of those who have fallen ill remain uncalculated. No link between the cancer of a particular individual and radiation is identified. No radiation accident has occurred. Neat and clean.

A theoretical example may serve to illustrate the underhanded deceptiveness of the Registry. An American goes off to fight for his country in Iraq. While on maneuvers, he ends up being downwind of a burning enemy tank, recently destroyed by a DU-penetrator fired from an M1A1 Abrams tank. The soldier ends up inhaling smoke and dust from the fire. Over the next 48 hours he begins to feel his health worsening. Maybe the inhalation event compromised his health. Maybe some other event on the battlefield was responsible. In any case, his condition persists and, after returning home, he is debilitated for years afterward.

The question: Is he a victim of a radiation accident, and if so, will his case ever find inclusion in the US Radiation Accident Registry?

The answer is a quite obvious no.

To be considered a victim of a radiation accident, you first have to be identified as having been exposed to radiation. It is a demeaning slap on the face of America's fighting forces that among the cohort of over 100,000 ill veterans from Operation Desert Storm in 1991 (and an undetermined number from the second Iraq war), no systematic investigation has ever been carried out to determine how many of them were contaminated with depleted uranium aside from those few dozen who carried DU shrapnel within their bodies from friendly fire incidents. To undermine this wall of silence, a small study was conducted by the Uranium Medical Research Center (UMRC) in Toronto, Ontario, and it found that 14 of 27 ill veterans tested positive for the presence within their body of depleted uranium nine years after their tour of duty (Durakovic 2002). This finding suggests that a link may exist between their internal contamination and their illnesses. The presence of DU in the bodies of these ill veterans suggests that, in the search for truth, further testing of this population is scientifically justified so that any correlations between levels of contamination and manifest symptoms may be determined.

If our theoretical GI was included in the study group of the UMRC and was found to be contaminated by depleted uranium, would he yet qualify as a victim of a radiation accident?

The answer is still no. The dose of radiation he received on the battlefield must first be ascertained to determine whether or not the internal contamination to his lung was sufficient to meet the dose criteria of the Registry. The stumbling block to this is that the military does not gather this type of dosimetric information. Further, nowhere are tests being conducted on bystanders in areas contaminated by depleted uranium to determine their body burdens of internalized radionuclides. Again, potential victims go unidentified.

To counter this criminal cover-up, the UMRC has published a series of studies that have definitively lifted the veil of the United States Government's crimes against humanity. Their first study, cited above, was published in the journal *Military Medicine* under the title "The Quantitative Analysis of Depleted Uranium Isotopes in British, Canadian, and US Gulf War Veterans." In that article, for the first time, a protocol was described for determining the body burden of depleted uranium in exposed veterans. Before its publication, no one was aware of a method of determining depleted uranium in the body as distinct from the uranium in nature that all of us carry within our cells. Since appearing in

print, the technique has been successfully reproduced in a number of labs around the world. UMRC then followed up this work with a second study published in the same journal entitled "Estimate of the Time-zero Lung Burden of Depleted Uranium in Gulf War Veterans by the 24 Hour Urinary Excretion and Exponential Decay Analysis" (Durakovic 2003). In this study, the authors outlined a method whereby the initial quantity of depleted uranium inhaled into the lung could be estimated by the current rate of excretion in urine of depleted uranium years after the exposure. The knockout blow to the cover-up of the hazards of depleted uranium appeared in a follow-up article "Differential Decay Analysis of the Alpha Dose of Depleted Uranium and the Neoplastic Risk in the Lungs of Gulf War Veterans" (Durakovic et al., 2003). In this study, the authors collected urine samples from 11 British, Canadian, and United States veterans. Approximately half of the subjects tested positive for the presence of DU. Of these, time-zero calculations were made to estimate the amount of depleted uranium these veterans had initially inhaled into their bodies. Then, a new method was outlined for calculating the radiation dose to their lungs. In one subject studied, a 24-hour urine specimen contained 0.150 micrograms of depleted uranium. This corresponded to an initial inhalation exposure of 1.54 milligrams. During the first year, it was calculated that the alpha radiation dose to the lung was 4.4 millisievert (mSv). The cumulative ten-year dose was 22.2 mSv. The conclusion was loud and clear: The results of medical studies of a randomly tested Gulf War veteran revealed that his battlefield inhalation exceeded the maximum permissible inhalation dose of uranium. By the rules of the game of the US Radiation Accident Registry, this veteran was the victim of a radiation accident!

Will he ever be listed as an accident victim in the US Registry? Tomorrow, will the sun rise in the West?

The results of the UMRC's studies suggest that perhaps thousands of veterans from the first Gulf War received inhalation doses of uranium beyond the permitted maximum. Then there were the wars in Kosovo, Afghanistan and Iraq Part Two. What about the innocent bystanders of these battlefields? What about the wars yet to come? To quote John Gofman: "The nuclear industry is conducting a war against humanity."

Tribute needs to be paid to the researchers of the Uranium Medical Research Center. If it had not been for their ongoing work, any government-sponsored studies conducted would have calculated the lung dose to veterans from DU inhalation by the unscientific and antiquated method outlined in the previous chapter. They would have applied mathematical prestidigitation to their calculations to create the illusion that the radiation dose to the lungs from depleted uranium was minuscule and the medical hazards insignificant. Humanity would have continued blithely on, ignorant of the crimes being perpetrated

in its midst.

The US Radiation Accident Registry is all smoke and mirrors. It is a cleverly constructed web of hocus-pocus illusion designed to implant a false understanding of the biological hazards of the nuclear enterprise. By a few simple rules, an impenetrable monolith of lies and deceit is created that disguises the true extent of radiation injury imparted to the unsuspecting population by the Cult of Nuclearists. It's a rigged game, the rules of which are as follows:

1. Radiation accidents occur only in controlled settings such as in industry or medical facilities.
2. Radiation accidents never occur as the result of radioactivity released into the environment.
3. For a radiation accident to occur, a victim must be identified.
4. The victim's dosage has to be measured or assessed by dose reconstruction.
5. The victim's dosage has to meet the dose criteria.

By these rules:

"Serious injury due to ionizing radiation is a rare occurrence."

If not illegal, the REAC/TS central registry is immoral. It intentionally misleads and misinforms. Researchers the world over consult the Registry's statistics for information regarding the frequency of radiation accidents, the types of accidents that occur, the sources of the radiation from which people are most at risk, the populations most vulnerable to radiation injury, the number of people who actually sustain injury and death, and so forth. This information in turn may be used as a basis for formulating public policy. Further, the misinformation of the Registry warps the public's perception of the dangers it is being exposed to by government and industry. This environment of lies makes fertile ground for the fielding of radiological weapons, for the people have no sound basis by which to judge the malignant nature of such weapons.

Somewhere in the ether resides the City of Phantoms. In it dwell the victims of radiation who went to their deaths not knowing what brought their demise. The US Radiation Accident Registry is designed to keep them buried, faceless and forgotten. But they are martyrs to the rise of the Cult of Nuclearists, perhaps but the first wave of horrors yet to come. In memorial, the remembrance of a few such populations of phantoms, ignored by the Registry, is warranted.

The development of the atomic bomb demanded that the United States secure for itself a domestic supply of uranium. Consequently, in the decade following World War II, the uranium mining industry burgeoned. Prospecting for uranium was galvanized by both a patriotic duty to contribute to America's defense and a uranium fever induced by the promise of riches that took hold of both seasoned mining companies and neophyte prospectors. Where before there was little uranium mining in this country, by the middle of the 1950s there were 2,500 mines in operation on the Colorado Plateau. What accompanied this rapid expansion was a public health tragedy that with responsible oversight could have been avoided. This was largely due to the fact that the documented knowledge gained in the European mines of Joachimsthal and Schneeberg of the relationship between uranium mining and lung cancer went virtually ignored in this country. The Atomic Energy Commission, with its finger on every aspect of the newly developing nuclear industry, ceded oversight of mining operations and safety to the states, traditionally responsible for occupational safety, and to the Public Health Service. However, neither possessed the expertise to oversee radiation safety in the mines. It took years for the state bureaucracies to organize themselves for proper oversight. And time passed while environmental monitoring was conducted in the mines and epidemiological studies were undertaken among miners. Even as it became clear that a potential health problem was in the making, mine operators resisted investing money in ventilation equipment and the power to operate it. Only at the end of the 1950s, when the AEC slowed its procurement of uranium and the uranium boom came to an end, did measures finally get instituted for mine safety. But by that time the damage had been done and an epidemic of lung cancers among uranium miners had been initiated.

Between 30,000 and 40,000 men, many Native Americans, sought employment in the uranium mines. Thousands more were employed in crushing plants and refining mills. Compounding the hazards of exposure to uranium, radon, and the decay products of radon were the often poor working conditions such as insufficient ventilation, poor sanitation, no washing facilities or changing rooms, contaminated drinking water, a lack of personal dust respirators, and inadequate education with regards to safety precautions (Eichstaedt). As a result, uranium miners suffered an inordinate incidence of lung cancers. At a minimum, 10 to 15 percent of them died of lung cancer. During the period 1950 to 1968, the incidence of lung cancer among US miners was approximately six times that of non-miners (Stannard). The average lifespan of miners was 46 years (Caufield).

To this day, the US government denies that army personnel who participated in mock military maneuvers "under the cloud" of atomic test detonations during the 1950s were exposed to a radiation hazard or that anyone suffered radiation injury. During weapon tests, radiation safety was predicated on the assumption that external radiation

from gamma and beta-gamma emitters was the principal health hazard, and if the dosage from these fell within the limits of safety then any hazard posed by internal contamination would be inconsequential. Historically, it is important to recognize that long after this assumption was shown to be erroneous, authorities played on the ignorance and naiveté of the general population and continued to tout the safety of ionizing radiation by intentionally ignoring the importance of internal contamination by radionuclides. This tactic is very much in evidence in Barton C. Hacker's 1994 book *Elements of Controversy* which is the official history of America's nuclear weapon testing from 1947 to 1974. The author repeatedly affirms that no participant out of a population of more than a quarter of a million men suffered radiation injury. He substantiates this argument by citing the available data gathered from film badges and survey meters of measurements of external gamma radiation that consistently recorded low levels of exposure. Hacker's explanation of events at the Nevada Test Site ignore the fact that records were not always carefully kept, that many participants never wore radiation detectors, that film badges were subsequently lost, that at least some of the survey meters used were not sensitive to exposures greater than 0.5 roentgen, and that a fire in 1976 destroyed the Federal Records Storage Center in St. Louis where radiation exposure records were housed. His argument for radiation safety relies on a tactic first practiced by the Atomic Energy Commission in the 1950s to assure people living downwind of the Nevada Test Site that radioactive fallout was not a health hazard. This act of legerdemain touts the safety of ionizing radiation by intentionally blurring the distinction between external and internal exposure. All mention of radiation to the public is framed in the context of radiation received from outside the body from irradiation by gamma rays. The hazard posed by radionuclides inhaled or ingested into the body is silently sidestepped. Hundreds of thousands of GIs spent time in the wind-blown desert of Nevada which was contaminated by a plethora of fission products, easily available for inhalation and ingestion. But this avenue of exposure is ignored as a possible causative factor of the diseases suffered by many of these veterans after their military service had ended.

Of all the US servicemen who eventually participated in atomic maneuvers up to the end of aboveground testing in the early 1960s, 6,000 of them filed claims with the Veterans Administration claiming health problems resulting from exposure to radiation. Only 44 of these claims were initially accepted. The remainder were rejected on the grounds that there was no evidence to confirm a link between their radiation exposures and their illnesses. Finally in 1988, Congress authorized the government to provide health benefits to any atomic vet who suffered from the types of cancer commonly acknowledged to be induced by radiation.

In November 1993, a series of articles appeared in the *Albuquerque Tribune* which disclosed the names of 18 Americans who had been injected with plutonium in the 1940s as

part of a secret medical experiment. The public clamor for more information eventually prompted the Department of Energy to release millions of pages of files documenting human radiation experiments performed during the Cold War. This information revealed that between 1944 and 1974, the Atomic Energy Commission conducted over 430 radiation experiments on over 16,000 people and condoned many hundreds of experimental releases of radiation into the environment. A majority of the people victimized by these experiments were unaware that they were guinea pigs. Most often they were not informed that they were being exposed to radiation in untested procedures that would likely offer no benefit to their medical condition. The potential health consequences of such exposure, if known by the experimenters, were not adequately explained to the patients. Informed consent was for the most part lacking. Many treatments were known to offer no medical benefit to the patient and were performed with the sole intention of surreptitiously gathering data on the human physiological response to radiation exposure. Some patients died miserable deaths. Others sustained serious injury. Most evidenced no immediate harm and provided much needed information on baselines for non-injurious doses and procedures. The apparent rationale for such a violation of medical ethics was that information about the medical effects of radiation was urgently needed so that safety guidelines could be established for the burgeoning nuclear weapons industry and the promising new field of radiation medicine. Experiments were undertaken for a number of purposes: to develop instrumentation for spying on the Soviet nuclear weapons complex, to design radiological weapons, to determine the functional capacity of soldiers and astronauts after being exposed to radiation, to study the occupational hazards of working with radioactive material, and to study the metabolism of radioisotopes.

The following are just a few of the experiments that were performed:

1. One set of experiments involved total body irradiation, purportedly to offer some medical benefit to the patient, but with the underlying agenda of providing information on the hematological effects of varying levels of radiation exposure. Between 1942 and 1946 at the University of California Hospital in San Francisco, 29 patients received multiple exposures to x-rays totaling between 27 to 394 roentgens. A similar experiment was conducted at the Argonne National Laboratory during 1943 - 1944. Fourteen subjects participated. Some received single doses of 27, 60 or 120 roentgens. Others received multiple exposures totaling either 100, 300 or 500 roentgens. Between 1951 and 1972, Total Body Irradiation studies were conducted on approximately 500 cancer patients on behalf of the military to provide data on human responses to radiation (Welsome). NASA took great interest in these studies which provided valuable data relating to continuous exposure to radiation, as would be encountered by future astronauts.

2. Between 1946 and 1953 at the Walter E. Fernald State School in Waltham, Massachusetts, 74 retarded and institutionalized boys were fed trace amounts of radioactive iron or calcium in their oatmeal. The MIT study was designed to study the metabolism of these minerals in the boys' diet. Parents of the children were asked to sign consent forms that did not delineate the purpose of the experiments or the possible risks and were misled into believing that the experiments could be helpful in improving the conditions of their children.

3. Between 1963 and 1971, 67 convicts at the Oregon State Prison received x-ray doses from between 8 to 600 rads to their testicles to determine the minimum amount of radiation required to cause permanent damage to human fertility and testicular function. It was known in advance that this level of exposure would cause damage to the prisoners' reproductive systems. The volunteer program provided $5 per month for each participant, $10 for each biopsy, and a $100 for a vasectomy at the end of the study. Similar research was performed at Washington State Penitentiary on 64 men between 1963 and 1969.

4. Radioactive iodine was intentionally released from the National Reactor Testing Station in Idaho in an experiment to simulate the effects of fallout. After cows grazed on the contaminated pastures for a number of days, their milk was gathered and fed to humans. In similar tracer studies sponsored by the University of Chicago and Argonne National Laboratory, solutions of strontium and cesium were fed to 102 subjects. At Hanford, human subjects were given radioactive fish to eat. At Los Alamos, 57 persons ingested small quantities of uranium-235.

5. In 1946 - 1947 at the University of Rochester, six patients with good kidney function were injected with uranium compounds in dosages known to be harmful, in an attempt determine the concentration that would produce renal damage. Similarly, from 1953 to 1957 at the Massachusetts General Hospital in Boston, 12 patients with terminal brain tumors were injected with uranium to determine the dose necessary to damage kidney function.

6. At the University of Chicago and the Argonne National Laboratory from 1961 to 1963, 102 people were fed fallout from the Nevada Test Site, simulated fallout particles incorporating radioactive compounds, or solutions containing cesium-137 or strontium-90, in an attempt to calculate the effects of fallout on the general population.

7. Tissue analysis studies were initiated in 1953 to measure the biological impact of fallout. Tissues of plants, animals and humans were collected from around the globe and analyzed for traces of radioactivity. In a total of 59 studies, the body parts of 15,000

humans were collected. Operation Sunshine, the largest of the studies, collected 9,000 samples of human bones, entire skeletons and 600 human fetuses. These samples were clandestinely acquired without the consent of next of kin.

Radiation accidents at government-operated facilities have long been a subject of heated controversy. From the Manhattan Project until today, the government of the United States has employed approximately 600,000 people in industrial facilities related to the production of nuclear weapons. The health and safety of this population began to be called into question when anecdotal evidence began appearing in the public domain about the increasing frequency of accidents, leaks, spills, fires, intentional and unintentional releases of radioactivity into the environment, unsafe working conditions, mounting levels of contamination in work areas, inadequate radiation monitoring and record-keeping, hazardous mismanagement of radioactive waste, and the lack of proper education of workers about the hazards to which they were exposed. Epidemiological studies on workers' health were conducted by the Department of Energy but these were controversial because of the conflict-of-interest involved since DOE was also the employer. In response, the Department of Health and Human Services in 1990 took over the management of the studies. A compilation of selected studies published in 1999 revealed that workers at certain facilities did evidence a statistically significant increased risk of dying from certain cancers and nonmalignant diseases when compared to the general population (Task Group 1; Alvarez). Studies conducted at some facilities also indicated that rates of cancer tended to rise as doses of radiation increased. This correlation was most in evidence at those facilities that kept the best records, had undertaken extensive radiation monitoring, and had meticulously documented workers' radiation exposure. Studies of uranium-processing workers showed increased risks of dying from kidney diseases and respiratory diseases, both malignant and nonmalignant. Ten studies displayed increased rates of radiogenic cancers of the blood-forming and lymph organs. Increased incidence of Hodgkin's disease and prostate cancer were also in evidence in some of the studies and were significantly correlated with radiation dosage. During the Clinton administration, the US government conceded that some nuclear workers may have incurred health problems related to their occupational exposure to radiation. The Energy Employees Occupational Illness Compensation Program Act of 2000 provided compensation for any workers employed by the Department of Energy, their contractors or subcontractors who had been employed at 14 of the nation's weapon facilities who suffered from any of 22 different kinds of cancer, beryllium disease or chronic silicosis. These workers were given $150,000 and future payment of all medical bills resulting from their illnesses.

From recently declassified documents, it has been learned that between 1943 and the mid-1950s, the US Government secretly hired more than 200 private companies

employing an estimated 10,000 workers to process and produce material for nuclear weapons production (Eisler). Many of these facilities lacked the knowledge or ability to handle safely the radioactive material that passed through their doors, and undocumented thousands of workers received doses of radiation hundreds to thousands of times above permissible levels. This was confirmed in classified Atomic Energy Commission reports researched and written at the time. For example, Simmonds Saw and Steel Company in Lockport, New York, fabricated fuel rods for the nuclear reactors producing plutonium at the Hanford facility. By the mid-1950s, they had heated and milled 25 to 30 million pounds of uranium and 30 to 40 thousand pounds of thorium. An AEC study found that the workers most at risk in this facility were inhaling uranium dust at levels 190 times the maximum allowable concentration and thorium dust at 40 times the federal limit. Similarly, workers at the Vulcan Crucible Tool and Steel Company in Aliquippa, Pennsylvania, were found to be breathing uranium dust 200 times the AEC's limit of safety.

Only a few follow-up studies were ever carried out to determine the long-term health consequences to workers at these non-government facilities who were exposed to radioactive contamination. One study completed in the early 1990s, of workers who did uranium refining at the Mallinckrodt Chemical Company in St. Louis, showed increases above the general population in lymphatic, laryngeal, esophageal and rectal cancers and a high incidence of kidney diseases (Alvarez; Eisler). High rates of cancer and respiratory ills were found in another study undertaken during the early 1980s among workers who processed uranium at Linde Air Products in Tonawanda, New York.

The US Radiation Accident Registry is a hoax. The legacy of the nuclear age is a mountain of unidentified corpses. The first limited nuclear war will add millions more to the list.

When will it ever end?

8

Are Uranium Weapons Made of Uranium?

The twenty-first Century is a complex time in which to live. In previous eras, it was relatively easy to identify monstrous acts of savagery. If a barbarian horde rode roughshod over a community and slaughtered 50,000 people, there would be no room for debate as to whether or not an atrocity had been committed. But in this century, carnage can be subtle and sublime. Crimes against humanity are perpetrated in the atomic realm, silently and invisibly. Thunderless cannonade by photons and subatomic particles, set off within the depths of a human body, decimate biomolecular structures and initiate disease processes. Debilitating illness, cancer, birth defects: these are the types of devastations delivered by the nuclear war waged beneath a victim's skin.

Depleted uranium is devilish in its complexity. It is not a simple substance and does not behave, once inside the human body, in simple ways. Muddled thinking frequently obscures the subject, even by professionals who should know better. Frequently, those who write about DU err by rendering the topic overly simplistic. Others, with more sinister intentions, gloss over the details so as to hide the vectors of DU's toxicity.

In the Earth's crust, uranium is present in the form of three different isotopes. In terms of their relative concentration, 99.2749% is U-238, 0.7196% is U-235 and 0.0055% is U-234 (Dietz 1999a). Wherever this natural, non-depleted uranium is found, the radioisotopes in its decay series are also present. The decay products of U-238 include thorium-234, protactinium-234, uranium-234, thorium-230, radium-226, radon-222, polonium-218, lead-214, bismuth-214, polonium-214, lead-210, bismuth-210 and polonium-210. Stability is finally achieved for each atom when it transmutes into lead-206. The

decay chain of U-235 is different. Its daughter products include thorium-231, protactinium-231, actinium-227, thorium-227, radium-223, radon-219, polonium 215, lead-211, bismuth-211 and thallium-207. This series reaches stability with lead-207. The half-life of U-238 is 4.49 billion years. The half-life of U-235 is 710 million years. The third isotope of uranium found in nature is U-234. It is a decay product of U-238. It is much less abundant than the other two uranium isotopes, and its half-life is 245,000 years.

After uranium-bearing ore is mined, it is transported to a uranium mill. Here, the uranium is chemically separated from the other material present in the rock, including its daughter radioisotopes, and concentrated into a product called "yellowcake." Yellowcake, a coarse powder, is approximately 80 percent triuranium octaoxide (U_3O_8). This uranium has the same relative concentrations of U-238, U-235 and U-234 as the uranium found in nature. The next step in the uranium fuel cycle is the conversion of yellowcake into usable fuel for nuclear reactors or bombs. For a small number of reactors, such as the Canadian CANDU reactor, uranium need not be enriched. For these, fuel pellets are produced simply by converting the uranium in yellowcake to uranium dioxide (UO_2) metal. The majority of nuclear reactors, however, require slightly enriched uranium to sustain their chain reaction. To achieve this, the relative concentration of U-235 in a mass of uranium must be increased from 0.7196% to between three and five percent. Certain types of nuclear weapons also require enriched uranium, and for these, the relative concentration of U-235 must exceed 90 percent.

The process of uranium enrichment first requires yellowcake to be converted to uranium hexafluoride (UF_6). UF_6 is a solid at room temperature. When heated to 134° F (57° C), it sublimes, entering a gaseous state. Either through the gaseous diffusion or gas centrifuge process, the lighter atoms of U-235 are separated from the heavier atoms of U-238 and then concentrated. As a consequence of the enrichment process, two different products are produced: enriched uranium and depleted uranium. Both leave the enrichment facility as UF_6. Enriched uranium contains proportionally more U-235 than the uranium found in nature. Depleted uranium is only "depleted" of a portion of its U-235 content. The relative concentration of the three isotopes of uranium in depleted uranium is as follows: 99.7947% is U-238, 0.2015% is U-235 and 0.0008% is U-234. These numbers can be somewhat variable. The definition of depleted uranium by the Nuclear Regulatory Commission is uranium with a U-235 content less than 0.72%. The Department of Defense requires that uranium used for military purposes have a U-235 content of less than 0.3%.

The differences between non-depleted and depleted uranium may be visualized in the form of the following table, reproduced from the IAEA website. It is important to note

that, during the enrichment process, what becomes depleted uranium is diminished of not only U-235 but also U-234. In nature, nearly half of the radioactivity of non-depleted uranium comes from U-234. By contrast, U-234 contributes only 15.2 % to the radioactivity of DU.

Isotope	Natural Uranium By Weight	Natural Uranium By Activity	Depleted Uranium By Weight	Depleted Uranium By Activity
U-238	99.28%	48.8%	99.8%	83.7%
U-235	0.72%	2.4%	0.2%	1.1%
U-234	0.0057%	48.8%	0.001%	15.2%

The non-depleted uranium that is present in nature is, for the most part, found in low concentrations in soil, rock and water. Its concentration is routinely measured in parts per million. According to the IAEA:

> The average concentration of natural uranium in soil is about 2 parts per million, which is equivalent to 2 grams of uranium in 1000 kg of soil. This means that the top meter of soil in a typical 10m x 40m garden contains about 2 kg of uranium (corresponding to about 50,000,000 Bq of activity just from the decay of the uranium isotopes and ignoring the considerable activity associated with the decay of the progeny. Typical activity concentrations of uranium in air are around 2 μBq per cubic meter. (UNSCEAR 2000). Most of the uranium in water comes from dissolved uranium from rocks and soil; only a very small part is from the settling of uranium dust out of the air. Activity concentrations of U-238 and U-234 in drinking water are between a few tenths of a mBq per liter to a few hundred mBqs per liter, although activity concentrations as high as 150 Bq per liter have been measured in Finland (UNSCEAR 2000). Activity concentrations of U-235 are generally more than 20 times lower (IAEA).

In contrast to the diffuse, unconcentrated presence of non-depleted uranium in the environment, depleted uranium UF_6 is 100% uranium after being converted to depleted

uranium metal. Although this fact is routinely swept under the table in discussions on the toxicity of DU, it is immeasurably important. Proponents of DU frequently justify the safety of these weapons on the grounds that human beings are constantly exposed to uranium and show no ill effects. This argument is fancy footwork, but ultimately, hokum. DU munitions contain uranium in concentrations that are hundreds of thousands of times greater than the non-depleted uranium found in nature. Thus, for those internally contaminated with DU, an extremely enhanced chemical and radiological burden is introduced into their physiology which goes far beyond anything produced by exposure to naturally present non-depleted uranium. With the possible exception of a small number of workers in limited sectors of the uranium fuel cycle and some who are involved in the fabrication of components for nuclear weapons, **no human being on planet earth receives <u>acute</u> internal exposure to <u>concentrated</u> uranium at levels comparable to those who inhale particles of DU.**

For a proper understanding of the enhanced radiological hazard of depleted uranium and the skullduggery that surrounds the subject, the radioactive properties of naturally occurring non-depleted uranium and DU must be compared. In the following chart, measurements are given for the total radioactivity and alpha radioactivity of various forms of uranium. Measurements are presented in two different units: MBq/kg (million disintegrations per second per kilogram) and mCi/kg (thousandths of a curie per kilogram). With minor variations, the information in this chart is presented in every technical article and

Uranium	Activity [MBq/kg]	Alpha-Activity [MBq/kg]	Activity [mCi/kg]	Alpha-Activity [mCi/kg]
U-238	12.4	12.4	0.335	0.335
U-235	78.4	78.4	2.12	2.12
Natural, Non-depleted Uranium with daughter products	50.4	25.2	1.36	0.681
Depleted Uranium with daughter products	39.3	14.4	1.06	0.389

Reproduced from V.S. Zajic. Review of Radioactivity, Military Use, and Health Effects of Depleted Uranium

textbook discussing the radiological properties of uranium. The total activity and alpha activity for U-238 in columns one and two and columns three and four are identical because uranium's total activity is by alpha emissions. The same is true for U-235. The line to focus on in this chart is the third one which is meant to represent the combined activity of natural uranium and the radioisotopes in its decay chain. As can be read from the chart, one kilogram of this material decays at a rate of 50,400,000 disintegrations per second and emits 25,200,000 alpha particles per second. By comparison, as seen in line four, the total activity of DU with its decay products is 39,000,000 disintegrations per second per kilogram and it emits 14,400,000 alpha particles per second. Applying a little math to the figures in the chart, the discovery is made that **<u>the total activity of DU is actually about 22% less than that of non-depleted uranium</u>**. When the alpha activity is considered independently of the activity of the daughter products, which emit beta and gamma radiation, its radioactivity is 43% less. **It is this difference in alpha activity, *when the beta and gamma emissions are conveniently ignored*, which is the source for the commonly cited observation that DU is 40% less radioactive than non-depleted uranium.**

In virtually every article written on depleted uranium, the author mentions that DU is 40% less radioactive than natural uranium. Technically, as we have seen, this is true if we confine ourselves to comparing their alpha activity. But this simple statement obfuscates true understanding of the enhanced hazard presented by exposure to DU. Consequently, it is necessary to keep battering the wall of misconceptions so that no misunderstanding remains about the difference between natural exposure to non-depleted uranium and unnatural exposure to depleted uranium. For the sake of clarity, let's ask this question: Where can we find in nature a kilogram of this so-called "natural" uranium that undergoes 50,400,000 disintegrations per second. For some, the answer will be startling: **NOWHERE!** A kilogram of natural uranium with its daughter products cannot be found anywhere in nature. The idea of a concentrated mass of natural uranium is an abstraction. Scientists, whose stock-in-trade is to deal in abstractions, frequently overlook the fact that some of their abstractions represent nonsense in the real world. This is a case in point. What the scientist is saying with this abstraction is that if he could gather together and concentrate into a single, one-kilogram mass the uranium found in nature and its daughter products, the activity of this material would be that listed in the chart above. But a kilogram of this material doesn't exist in nature. Typically, uranium is found in soil or water as a few parts per million. Typical ore mined in the United States ranges from 0.05 - 0.3% uranium.

Once uranium-bearing ore is mined, it is transported to a mill where it is crushed and chemically treated in the first step of the refining process. At this point, the uranium

is separated from its decay products and possesses only 15 percent of the radioactivity that it would have had as concentrated "natural" uranium. The remaining 85 percent of the radioactivity is discarded in mountains of waste known as uranium mill tailings. After uranium is milled, it is shipped to conversion facilities where the uranium is put through further refining processes and then converted into concentrated, pure "natural" uranium. It is only at this point where "natural" uranium is truly born. This uranium will be composed of the three isotopes of uranium found in nature and will be more radioactive than DU due to its greater concentration of uranium-235 and uranium-234. When made into metal, the specific activity of this "natural" uranium is approximately 670 nanocuries per gram (Makhijani and Smith 2004). This activity translates into 24,790 disintegrations per second per gram. According to Makhijani and Smith: "The specific activity of DU can vary, but it is always greater than 340 [the specific activity of uranium-238] and less than 670 nanocuries per gram." In other words, the specific activity of DU falls within the range of between 12,580 and 24,790 disintegrations per second per gram.

So now we must ask: "Who exactly is it that is exposed to this so-called 'natural' uranium?" The number is relatively small: workers in certain sectors of the uranium fuel cycle, some employees at facilities producing components for nuclear weapons, some workers at chemical supply companies and perhaps some people in education, research or industry who use uranium and uranium compounds in the course of their work. Outside of this small subpopulation of human beings, no one on earth is exposed to "natural" uranium in any quantities other than the trace amounts found in nature. In contrast, all people present on the contaminated battlefield and those downwind are at risk of internal exposure to pure uranium metal. When this material is inhaled, the exposure is totally unnatural. The internalized particles are concentrated uranium. Once embedded in tissue, they act as point sources of radiation, and their level of radioactivity far exceeds that from naturally occurring uranium in the environment. **No one else on Earth receives such exposure to uranium as those contaminated by battlefield DU.**

Let's take it even further. If we did manage to acquire a kilogram of natural uranium, would it be more or less hazardous than a kilogram of depleted uranium? By conventional wisdom, the obvious answer would be non-depleted uranium because it is 22% more radioactive. But this is not true. We are once again dealing in irrelevant abstractions. Without question, the depleted uranium would pose the greater hazard. How can this be? Battlefield DU is put through a unique transformative process which masses of natural uranium never undergo. When DU munitions strike their target, they are burned and pulverized into microscopic-sized particles. This sets the stage for a unique exposure scenario. Of all possible configurations, a mass of material presents a greater and greater surface area when broken down into a collection of smaller and smaller particles. The inhalation of

pure uranium metal in the form of microscopic particles creates the maximum surface area for the quantity of uranium internalized to come into direct contact with the internal molecular architecture of the body. This geometry facilitates the greatest possible number of chemical interactions between the DU particles and nearby biomolecular structures and allows the maximum amount of radioactivity to escape the mass of each particle and bombard nearby cells. Such folly: after the expenditure of exorbitant amounts of money, energy and human labor to extract and concentrate the diffuse quantities of uranium found in nature, DU munitions redisperse uranium back into the environment, but this time, in a more toxic configuration.

If an honest comparison were to be made between typical human exposure to the uranium found in nature to the atypical exposure suffered by those inhaling the debris of DU weapons, one would discover that DU emits substantially more radioactivity. To help to clarify this, the specific activity of uranium isotopes in a gram of soil is 0.7 picocuries, or put more simply, **0.025 disintegrations per second per gram** (Todorov and Ilieva). The specific activity of 0.2% uranium ore is 4.0 nanocuries per gram (Makhijani and Makhijani 1996). This includes all decay products of uranium-238 up to and including radium-226, assuming they are in secular equilibrium with uranium-238. Mathematically, this translates into **148 disintegrations per second per gram**. Now to complete the picture, let us compare the radioactivity of these naturally occurring concentrations of uranium to the radioactivity of depleted uranium. For the sake of convenience, we can estimate the specific activity of depleted uranium to be 360 nanocuries per gram. This is a rough approximation. According to Makhijani and Makhijani:

> The radioactivity per unit weight (called specific activity) of depleted uranium metal is dominated by its principal constituent, uranium-238. It also depends somewhat on the exact extent to which uranium-235, and hence also uranium-234, have been separated and passed into the enriched uranium stream. It may vary from about 360 nanocuries/gram to about 450 nanocuries/gram. Even assuming that only uranium-238 remains, the specific activity would be still about 340 nanocuries/gram.

Using 360 nanocuries per gram as the specific activity of DU, this translates into **13,320 disintegrations per second per gram**. To receive equivalent exposure to this gram of DU, you would need to take into your body 532,800 grams of soil. Those who discount the hazard of DU based on the argument that humans are routinely exposed to uranium without ill effect are attempting to hypnotize humanity with balderdash.

It has so far been established that depleted uranium consists of the three naturally occurring isotopes of uranium. Although differing in their half-lives, each decays by emitting an alpha particle with an energy exceeding 4.0 MeV. As each atom decays, it transmutes into another element. Thus, with the passage of time, a mass of DU begins to accumulate trace quantities of its decay products.

When depleted uranium exits the enrichment facility, it is in the form of UF_6. At this point, it has been stripped of its decay products. According to Dietz (1999), when this uranium hexafluoride is chemically reduced to DU metal, the decay chain of uranium-238 is broken once again. The melting and reprocessing of this metal into DU ammunition breaks the decay chain yet another time. Thus, to inventory the decay progeny in battlefield DU, one must start from the time that DU munitions are manufactured. As each uranium-238 atom in a DU munition undergoes radioactive decay, it emits from its nucleus an alpha particle which consists of two protons and two neutrons. Thus, the newly transformed atom has an atomic number which has been reduced by two and a mass number which has been reduced by four. Thus, an atom of thorium-234 replaces each transmuted atom of uranium-238. With the passage of each second, thorium-234 begins to accumulate in freshly manufactured DU munitions. Simultaneously, atoms of this thorium-234 begin to undergo radioactive decay. The half-life of thorium-234 is relatively short, 24.10 days. When each atom decays, it emits a beta particle with an energy of approximately 0.20 MeV. It also emits a gamma ray of less than 100 keV. This beta decay transforms one neutron in the nucleus of a thorium atom into a proton. Thus, its decay product, protactinium-234m, has an atomic number one greater than the thorium isotope but a mass number that remains the same. Protactinium-234m has a half-life of 1.17 minutes. It also has two decay states. (The "m" represents "metastable" and indicates that the nucleus exists in an excited state.) Over 99% of the time, protactinium-234m decays to uranium-234 by emitting a beta particle with an energy of 2.29 MeV. This transformation is accompanied by the emission of a gamma ray with an energy of approximately 1.0 MeV. Less than one percent of the time, protactinium-234m undergoes an isomeric transition, reducing the extra energy in its nucleus from its excited meta state to its ground state, by emitting a gamma ray of 0.0694 MeV. Transformed now into protactinium-234, it has a half-life of 6.7 hours. When decaying to uranium-234, it emits a beta particle of 0.23 MeV.

The significance of the gamma emissions from DU is eloquently described by Dietz and deserves repetition:

> Gamma rays become absorbed in body tissue as follows. If their energy exceeds 40 keV, part of the gamma-ray energy is transferred to an atomic electron, setting it in high-speed motion (1 keV = 1000 electron

> volts energy). The remaining energy is carried off by a new gamma ray. This process, called the Compton effect, repeats until the gamma ray has an energy below about 40 keV where the photoelectric effect dominates and the remaining energy can be transferred to a photoelectron. For example, using Gofman's method (Gofman 1990), one can calculate that an 850 keV gamma ray absorbed in body tissue will produce a packet of high-speed Compton electrons and a fast photoelectron that on average can traverse 137 body cells. By contrast, according to Gofman, X-rays commonly used in medical diagnosis have a peak energy of 90 keV and an average energy of 30 keV (Gofman 1990). A 30 keV X-ray in body tissue can be converted into a photoelectron of this energy, which on average can traverse only 1.7 cells. Ionization along the tracks of high-speed electrons in tissue can cause damage to genetic material in the nuclei of cells. Thus, a high energy gamma ray from Pa-234 is much more penetrating than a typical medical X-ray and can damage far more living cells. The many 2.29 MeV beta particles emitted by Pa-234 are extremely penetrating in body tissue (1 MeV = 1 million electron volts energy). Referring to the experimental data given by Gofman (Gofman 1990), each one of these beta particles can traverse more than 500 body cells.

Depleted uranium, we now have discovered, consists not only of the three naturally occurring isotopes of uranium but also trace quantities of thorium-234 and protactinium-234m (or protactinium-234). These isotopes, due to their short half-lives, add to the radioactivity emitted by DU. When a DU penetrator is manufactured, it is stripped of the decay progeny of uranium. It consists of over 98 percent uranium-238 with the remainder consisting of uranium-235 and uranium-234 and the other nonradioactive metals with which it is alloyed. Within this mass, as the uranium-238 decays, the presence of thorium-234 and protactinium-234m begins to increase. Each second, using Dietz's numbers, a gram of uranium-238 undergoes 12,430 disintegrations per second. What needs to be established is the rate of decay among the increasing population of thorium and protactinium atoms. Interestingly, a state of "secular equilibrium" is reached within a relatively short period of time. Secular equilibrium is achieved only when an isotope with a relatively long half-life decays into a daughter isotope with a half-life that is much shorter. As the parent isotope decays, the population of the daughter isotope increases. However, due to its own rate of radioactive decay, the daughter population is simultaneously decreasing. When the population of the daughter isotope reaches a level where it is decaying at the same rate that it is being produced, so that overall, its quantity remains constant, secular equilibrium is achieved. Secular equilibrium occurs between uranium-238 and thorium-234 when they begin undergoing the same number of disintegrations per second, 12,430. Similarly, secu-

lar equilibrium is established between thorium-234 and protactinium-234m. By the end of 30 weeks, all three isotopes are disintegrating at the same rate. (Because the half-life of uranium-234 is 246,000 years, its presence does not increase rapidly enough to further add to the radioactivity of a mass of uranium-238.) Dietz presents the progression toward secular equilibrium in a mass of uranium-238 in the chart below.

Radioactivity (disintegration per second) in one gram of uranium-238 with no decay progeny initially present.

Weeks	U-238	—>	Th-234	—>	Pa-234	—>	U-234
0	12,430		0		0		0.000
1	12,430		2,270		2,150		0.000
5	12,430		7,890		7,840		0.001
10	12,430		10,770		10,750		0.004
15	12,430		11,830		11,820		0.007
20	12,430		12,210		12,210		0.010
25	12,430		12,350		12,350		0.013
30	12,430		12,400		12,400		0.017

The significance of this chart must be grasped if one wishes to fully understand the enhanced radiological hazard of depleted uranium when compared to the less concentrated forms of uranium found in nature. A gram of uranium-238 which has been stripped of its decay products emits 12,430 alpha particles per second. With the passage of time, the growing population of thorium-234 and protactinium-234 begins undergoing radioactive decay, and with each disintegration, each isotope emits a beta particle and a gamma ray. By the time 30 weeks have elapsed, all three isotopes are decaying at the same rate. At this stage the gram of uranium-238 at each second is emitting 12,430 alpha particles, 24,860 beta particles and 24,860 gamma rays.

Often one reads that the alpha emissions from a particle of DU are only capable of traversing a few cell diameters. Thus, only cells in the immediate vicinity of an embedded particle are at risk of injury or destruction. But this conception is incomplete. A particle of DU is continuously emitting alpha, beta and gamma radiation in a spherical volume

around the particle that encompasses hundreds of cell diameters. The inhalation of hundreds of thousands or millions of such particles creates a situation where a large number of body cells surrounding each particle are exposed to an ongoing barrage of radiation which may continue for years. Only by relying on the fraudulent concept of "dose" can those who advocate for the use of DU weaponry discount as insignificant this open-ended assault on biology.

The radioactivity of depleted uranium is further enhanced by the spontaneous fission of uranium-238. Spontaneous fission is a form of radioactive decay where the nucleus of a heavy atom spontaneously splits into two smaller nuclei. The byproducts of this process include free neutrons, gamma rays and other nuclear fragments such as alpha and beta particles. This event is relatively rare, but it might nonetheless have important biological consequences when occurring inside the human body. According to the European Nuclear Society, within each gram of uranium-238, one atom undergoes spontaneous fission every 2.5 minutes. This translates into roughly 210,240 spontaneous fission events per gram per year. This highly energetic process releases nearly 40 times the energy of the radioactive decay of a uranium atom. Thus, each spontaneous fission event of internalized DU releases approximately 160 MeV into tissue.

We have inventoried the radioisotopes in a mass of depleted uranium and presented a basic picture of their radioactivity. In a better world, this chapter would now be concluded. But DU is an insidious weapon with many stories to tell. The quickest entrance into one of America's dirty little secrets is by way of a riddle: In 1999, what did our NATO allies fighting in Kosovo and workers at the Paducah Gaseous Diffusion Plant in Kentucky have in common? Answer: They both learned for the first time that their exposure to "uranium" included exposure to the transuranic isotopes americium-241, neptunium-237, plutonium-238, plutonium-239, the fission product technicium-99 and the fission activation product uranium-236. In the case of Kosovo, this discovery came in the aftermath of the war when two laboratories analyzing spent DU rounds discovered traces of plutonium. Disclosure of this finding ignited the ire of representatives of NATO countries who had been kept oblivious of the fact that DU was something other than it seemed. At Paducah, workers also learned that the uranium with which they worked was contaminated, and this generated concern that this material might have accumulated to unsafe concentrations at various work stations throughout the plant. In response, the Department of Energy undertook a study which was first published in 2001 as "A Preliminary Review of the Flow and Characteristics of Recycled Uranium Throughout the DOE Complex: 1952-1999." This study let the whole world in on the secret that the entire US stock of depleted uranium was contaminated with transuranics and fission products.

As the DOE tells the story, uranium was scarce relative to demand when the United States began developing nuclear weapons. In 1952, as the Cold War began in earnest and bomb production accelerated, a program was initiated at the Hanford Site in Washington State for recovering uranium from spent reactor fuel, targets and discarded high-level radioactive waste. In time, recovery programs spread to the Idaho National Engineering and Environmental Laboratory, Idaho; the Savannah River Site, South Carolina; and the West Valley Demonstration Project, New York. Chemical separation plants at these four sites separated, concentrated and recovered plutonium and uranium from the fission products and other transuranic isotopes which had accumulated in the spent nuclear fuel and targets. However, separation was never 100%, and the recovered uranium contained trace concentrations of plutonium, other transuranics and fission products. From the chemical separation plants, the contaminated uranium flowed to three principal types of processing facilities: the gaseous diffusion plants, the feed manufacturing facilities and the component fabrication facilities. The eight sites involved were the Paducah Gaseous Diffusion Plant (GDP) , Kentucky; the Oak Ridge GDP, Tennessee; the Portsmouth GDP, Ohio; the Feed Materials Production Center at Fernald, Ohio; the Oak Ridge Y-12 Complex, Tennessee; the Rocky Flats Plant, Colorado; the Weldon Spring Site Remedial Action Project, Missouri; and Reactive Metals, Inc., Ohio.

Between March 1952 and March 1999, the four chemical separation plants shipped 130,000 metric tons of the impure recycled uranium to the processing facilities. At the three gaseous diffusion plants and the feed manufacturing facilities, this uranium was blended with natural uranium that had never before been through a reactor. This raised the total inventory of the contaminated product in the DOE complex to 250,000 metric tons of recycled uranium. At the three gaseous diffusion plants, the contaminated recycled uranium was fed into the enrichment process. A portion of the transuranics and fission products contained in this feed material entered into the depleted uranium stream. This was the source for the contaminated DU now scattered in Iraq, Bosnia and Kosovo and many gunnery ranges throughout the United States.

The exact composition of the DU being scattered around the globe is open to question. Hints of this come from the DOE:

> The flow of uranium among DOE sites and within various streams at individual sites was extremely complex. Processing sites used recycled uranium to create materials for reactor fuel and weapons components and shipped the materials to other DOE sites. Since processing normally required multiple steps and production optimization, the sites also interchanged materials among themselves. Operations within

> DOE frequently and deliberately concentrated the isotopes, diluted them, and blended them with natural uranium, in some cases increasing the total amount of uranium containing transuranics/fission products in the complex. **Data on transuranics/fission product levels are incomplete; DOE did not track the trace quantities of transuranics and fission products other than ensuring plutonium concentration to be less than the 10 per billion specification** [emphasis added] (US DOE).

There is no uniformity in the composition of DU. One batch may differ significantly from another. DOE claims that within the current inventory of DU only trace concentrations, measured in a few parts per billion, are present of neptunium-237, plutonium-238, plutonium-239, plutonium-240, americium-241 and technicium-99. In the absence of analysis by independent parties, the public is forced to accept affirmations by the DOE that the concentration of plutonium in DU is less than one part per billion, that of neptunium-237 is less than five parts per billion and that of technicium is less ten parts per billion. Analysis of a small number of DU munitions recovered in Kosovo revealed similar trace levels. Cautiously, the Royal Society offers this observation: "However, independent analyses of the levels of these contaminants in DU munitions are required to confirm that the reported levels are not significantly exceeded in other batches of penetrators." According to the WHO, the radiation dose from the transuranic and fission product contamination of DU contributes less than a one percent increase in the radioactivity of a DU munition.

Objective nature is a tool for truth in a world of falsehood. When uranium is present in a nuclear reactor, the nuclei of atoms of uranium-235 capture neutrons and are transformed into uranium-236. Uranium-236 does not occur in nature. However, it is present in DU munitions manufactured from recycled uranium. Thus, its presence is a signature that the uranium in biological samples originated not from nature but exposure to depleted uranium waste from the nuclear fuel cycle. Contamination with uranium-236 testifies in every instance that exposure to weaponized uranium has occurred.

Depleted uranium is a witch's brew of radioisotopes. And yet, these do not complete DU's toxicological profile. DU munitions are the delivery vehicle for a much broader inventory of toxic chemical compounds. These will be discussed in the chapter devoted to the health effects of DU. Enough has been revealed, however, to raise an important point. Depleted uranium is a unique hybrid for which no natural or manmade analogue exists. As such, the relevance of much of the research cited to demonstrate that exposure to DU produces no malignant effects needs to be questioned. Uranium miners or people living in areas with unusually high levels of uranium in soil and water are receiving, both

qualitatively and quantitatively, a different type of exposure than those who inhale battlefield DU. Granted militarized uranium is approximately 98 percent uranium-238. Nonetheless, it is more concentrated, more radioactive and laced with trace quantities of a number of unnaturally occurring radioisotopes. No other example of uranium exposure is sufficiently analogous to reasonably be used as a substitute to explain away DU's toxicity. Thus, much of the pre-1991 research on uranium exposure may be irrelevant in assessing the medical effects of DU.

Similarly, since the First Gulf War, a renewed interest has arisen in the toxicology of uranium. New research is being conducted in numerous labs throughout the world. This is valuable work and needs to be encouraged. However, when one reviews the published literature, a glaring deficit emerges. Nearly all of the research initiatives are based on *in vitro* and *in vivo* studies using a variety of purified chemical compounds of uranium. These compounds are acquired from chemical supply companies. Although useful for investigating the chemistry and radiological effects of uranium, these may fall short in reproducing the biological effects produced by depleted uranium munitions. Battlefield DU is a dirty material. A realistic picture of its toxicity may not emerge from studies relying upon purified compounds of uranium. Consequently, spent rounds of depleted uranium and battlefield debris contaminated with DU must be the substances used to evaluate the toxicity of militarized uranium.

9

Afghanistan: An Unfolding Medical Mystery

To catch a glimpse of the inhumanity and depravity living within the hearts of those who attack civilian populations with radiological weapons, elements of their methodology must be brought to the light of day. For these people, wars are their canvas. Their exotic weapon systems are their palette. And the nuances of destruction and the varieties of the chronic illnesses and congenital malformations that they cause are their compositions. There is perhaps no clearer example of this terrible artistry than the bombing that took place in Afghanistan.

In the aftermath of the destruction of the World Trade Center on September 11, 2001, the United States declared a war on terrorism and invaded Afghanistan, waging a campaign that came to be known as Operation Enduring Freedom. As part of its aerial offensive, the United States targeted numerous sites with highly accurate precision guided weapons, which in previous conflicts were suspected of containing depleted uranium. Further, to flush enemy forces from entrenchment within mountain caverns, an unknown number of deep penetration "bunker buster" bombs were dropped. Each of these ordnances was suspected of containing from hundreds to thousands of pounds of an unidentified "dense metal," the exact composition of which has yet to be made public (Williams 2002a, 2002b). The number of bombs detonated and the total tonnage of the mystery metal released in Afghanistan remains classified information. It is widely known that the United States maintains within its arsenal munitions fabricated from uranium alloys. Concerned parties initially assumed that depleted uranium was once again being scattered across the environment as had taken place in Iraq, Bosnia and Kosovo.

To conduct preliminary research into the possible health effects from the bombing, the Uranium Medical Research Center of Toronto, Ontario, dispatched a field team in June 2002 to the area of Jalalabad, Nangarhar Province, in eastern Afghanistan. At that time, 24 hour urine samples were collected from eight male civilians who had reported becoming ill after being exposed to dust and smoke emanating from targets destroyed by US bombs. All eight test subjects manifested symptoms of fatigue, fever, musculoskeletal pain, neurological alteration, headaches and respiratory impairment (Durakovic 2005). The initial symptoms that each developed soon after the bombing raids included a burning sensation in the nasopharyngeal region, nosebleeds and a dry, nonproductive cough that persisted for several weeks. The urine samples, plus soil samples from the bomb sites and water samples from the village culvert, were sent for analysis to the Geoscience Laboratory of the National Environmental Research Council in England. Sophisticated testing was conducted by multicollector, inductively coupled plasma ionization mass spectrometry, a procedure sensitive enough to determine the relative concentrations in the samples of the radioisotopes U-234, U-235, U-236 and U-238. The ratio of U-238 to U-235 in all samples was calculated to be 137.87 plus or minus 0.07, and the ratio of U-234 to U-238 was 0.000055 plus or minus 0.000001. These figures were consistent with values for the uranium found in nature normally occurring within the human body. The isotope U-236, which is present in depleted uranium but not the uranium found in nature, was not detected. Together, these findings confirmed that the test subjects had not been exposed to depleted uranium. Nevertheless, the urine samples told a mysterious and very disturbing tale. When the total uranium concentration in urine was calculated, the values ranged from 88.52 to 477.88 nanograms per liter, with a mean value of 275.04. By comparison, the Afghan control value for the study was 11.88 nanograms per liter. By some unidentified avenue, the test subjects had taken into their bodies unusually large quantities of non-depleted uranium which they were gradually excreting through their urine at levels that were significantly elevated above normal.

The analysis of soil and water samples similarly displayed the presence of uncharacteristically high levels of non-depleted uranium. Drinking water found close to the bombed sites had a measured value of 38,277 nanograms of uranium per liter. This was in sharp contrast to the World Health Organization's recommended drinking water standard of 2,000 to 9,000 ng/L. Soil samples showed a range of uranium values between 2.3 and 18.6 mg/kg. As a reference, the world average is between 1.8 to 3.0 mg/kg.

As discussed earlier, in the event that a person absorbs an unnaturally high dose of uranium, the body immediately begins to eliminate it. Abnormally high levels of internalized uranium are reflected by an elevated concentration of the element in the urine. As the body proceeds to rid itself of the excess, its progress can be monitored over time by repeated

measurements of urine samples which will manifest a steadily decreasing concentration of uranium. Eventually, the uranium concentration will return to within the normal range which is maintained by the steady ongoing intake and elimination of uranium from the diet and the steady binding and releasing of uranium from the tissues of retention. Given this fact, **it is likely that had the UMRC field team arrived a year later and measured the total concentration of uranium in the urine of the ill people they encountered, measurements would have been within the normal range. It would have been impossible to detect that these people had been contaminated by elevated doses of natural uranium**. As established in an earlier chapter, measuring the total concentration of uranium in the urine is a valuable diagnostic test only when performed soon after exposure. Performed years after exposure, it is valueless in providing any information about exposure history. (The exception to this would be people retaining uranium shrapnel in their body which would continually be leaching uranium into the circulation and creating an ongoing elevation of uranium in the urine.)

In October, four months after the first field trip, UMRC dispatched a second team to Afghanistan to conduct further research. During this trip, 24 hour urine specimens were collected from 22 male test subjects from one area of Jalalabad and three areas of Kabul. Kabul, the capital city with a population of 3.5 million people, had within its perimeter a high concentration of targets which had been destroyed by precision guided weapons which were thought to contain uranium alloys. All test subjects had been in close proximity to targets at the moment when they had been destroyed and all had inhalation exposure to dust and smoke produced from the bomb blasts. Each displayed nonspecific multi-organ alterations of the respiratory, musculoskeletal, urinary, immune and neurological systems (Durakovic *et al.*, 2004d). Three non-symptomatic subjects who had not been in the areas of the bombings provided urine samples and served as the study's controls. Geological samples of water, soil and silt were also collected to gain an understanding of the distribution of uranium in relationship to the bomb craters. The mean concentration of total uranium in the urine of the test subjects was determined to be 221.50 plus or minus 91.05 ng/L compared to the control value of 32.06 plus or minus 14.8. In the samples from Kabul, total uranium concentration ranged from 30 to 100 ng/L. In Jalalabad, the range was between 100 and 300 ng/L. Urine analyzed from a child from Kabul, the sole survivor of a bomb hitting his family's home, showed an exceedingly high total uranium concentration of 2031.63 ng/L. The relative concentration of uranium isotopes in the Jalalabad samples was consistent for that of non-depleted uranium, i.e., no evidence of depleted uranium was found. In seven samples from Kabul, there was a small detectable presence of uranium-236, evidence that depleted uranium had dusted the area.

During the course of their investigations, the UMRC field team interviewed a num-

ber of people who had witnessed US bombing raids. Their reports were remarkably consistent. When a bomb detonated, witnesses observed a characteristic green flash followed by large, dense clouds of dust and smoke rising into the air. The prevailing winds then carried these plumes, like a thick fog, across adjacent agricultural fields and through neighborhood villages. As people became engulfed in these clouds, they became immediately aware of an acrid smell and an immediate burning sensation in their nasal passages, throats and upper respiratory tracts. Exposure was quickly followed by nosebleeds which persisted for one or two days. Runny noses and nasal congestion followed which lasted from a few weeks to a number of months. People inhaling the material from within these clouds also contracted a cold or flu-like illness that persisted over a similar time frame. Particularly interesting was the discovery that the irritant released by the bombs lingered in the environment. When the UMRC field team arrived in Kabul many months after the bombing, they themselves began to experience nosebleeds and respiratory problems almost immediately. When visiting bomb craters to collect soil samples, they felt burning sensations in their noses and throats. When handling soil, shrapnel, and other debris, they felt a burning sensation on the skin that required numerous washings to fully remove the irritant. Skin rashes developed afterward that remained for many weeks.

Members of the field team reported that they became increasingly alarmed by the number of ill people they encountered dwelling in proximity to every bomb site they visited. A majority of these people reported symptoms identical to those of GIs exposed to depleted uranium in the Gulf. Questioned as to the onset of their symptoms, all reported becoming sick within minutes or hours after being exposed to bomb debris, and that their illnesses had continued unabated since that time. All presented similar symptoms and described identical chronologies for the onset and course of their sickness. In the wake of the bombings, a flu-like illness rapidly developed and swept through entire neighborhoods adjacent to the target destroyed by US bombs. Symptoms which later developed included pain in the basal area of the skull, neck, and upper shoulders; pain in the lower back and area of the kidneys; joint and muscle weakness; sleeping difficulties; headaches and memory problems accompanied by confusion and disorientation. Further, there were reports that women in these areas later gave birth to a disproportionate number of babies with congenital and postnatal health problems. The future good health of the children growing up in these areas is a topic of enormous concern. Children were frequently observed playing in bomb craters where the soil later tested positive for the presence of unnaturally high levels of uranium.

The situation described by the UMRC field team represents a medical mystery. What is in the munitions that is creating these health problems? Is internal contamination by uranium the cause? Is it the sole cause? Is some unidentified chemical agent present

within the munitions that is toxic to those exposed? Is some chemical reaction among bomb components taking place at the moment of detonation that is either intentionally or unintentionally creating toxic substances that are released into the environment? Are biological weapons being secretly incorporated within uranium munitions in some yet unidentified toxic brew?

Failing to find an explanation for the natural presence for the high levels of uranium that had been detected in all the samples analyzed, the field team proposed the following hypothesis: The uranium contamination in test subjects, soil, and water had been produced by the weapons detonated during the bombing raids. These weapons were made not of depleted uranium but non-depleted uranium, something never before discovered or conceived to exist within the arsenal of the United States. It was the members of the field team who first coined the name "non-depleted" uranium to describe weaponized natural uranium.

Durakovic summarized UMRC's findings in an article entitled "Undiagnosed Illness and Radioactive Warfare":

> UMRC's studies of the population of Jalalabad, Spin Gar, Tora Bora and Kabul areas have identified civilians suffering from the same multi-organ, nonspecific symptomatology encountered in the Gulf War I and the Balkan conflicts. The symptoms included physical weakness, headache, muscular and skeletal pains, respiratory changes, fever, persistent dry cough, chest pain, gastrointestinal symptoms, neurological symptoms, memory loss, anxiety and depression.
>
> The first results from the Nangarhar Province revealed significantly increased urinary excretion of total uranium in 100% of the subjects, exceeding an average of 20 times higher values than in the nonexposed population. The analysis of the isotopic ratios identified non-depleted uranium. Subsequently, studies of specimens collected in a second field trip in 2002 revealed uranium concentrations up to 200 times higher than in the control population. These high levels of total uranium excretion have been identified in the districts of Tora Bora, Yaka Toot, Lal Mal, Makam Khan Farm, Arda Farm, Bibi Mahro, Poli Cherki and the Kabul airport districts. Both fieldtrips revealed identical signatures of non-depleted uranium (NDU) in all areas of study in eastern Afghanistan.

Detractors of the UMRC research vocally proclaimed that US munitions could not possibly have been responsible for the elevated levels of non-depleted uranium found in the

test subjects and the environmental samples. With the intention of discrediting UMRC, they proposed that elevated levels of non-depleted uranium had been present in the environment prior to Operation Enduring Freedom and had been overlooked by sloppy research. According to these critics, this hypothetical naturally occurring uranium in the environment was responsible for what was wrongfully being ascribed as weapon contamination.

In fact, the field team had considered this possibility but found it untenable. Here's why. Human beings living in different locales exhibit differences in the trace amounts of uranium they carry within their bodies and the amounts they regularly excrete in their urine. This is primarily a result of differences in local geology which are responsible for the concentration of uranium present in soil, vegetation and water. Taking this into account, the UMRC field team meticulously investigated all possible sources for exposure to non-depleted uranium in an attempt to explain the data they had collected (Weyman 2002). An investigation of the local geology in the areas which were bombed produced no evidence that the uranium found in nature was present in higher concentrations than in neighboring outlying areas that hadn't been bombed. The testing of local sources of drinking water and water flowing in *karaizes* (hand-dug, underground channels bringing mountain water to the agricultural plains) demonstrated that elevated concentrations of uranium were not naturally transported into the war zones from more distant locations. The field team also searched for possible uranium mining or processing facilities which could have been responsible for polluting the area with elevated concentrations of natural uranium. But no uranium industry existed anywhere near the bomb sites. Uranium ore deposits had been identified in Helmand Province but this was several hundred kilometers to the south. Exploring other possible explanations, the UMRC researchers determined that there was no local mining of phosphate, limestone, or gypsum in the area of Jalalabad. Secondary manufacturing and local use of these products was also not in evidence, although phosphate fertilizers may have been used abundantly in the past. In addition, no major excavation projects were in evidence in the areas where high levels of contamination had been detected. The field team considered statements from the US government that Al Qaeda had attempted to assemble a dirty bomb containing waste from a nuclear reactor. But this explanation was also discarded because the isotopic ratios, decay products, and transuranic elements present in reactor waste were not consistent with the natural uranium detected in the collected urine samples.

The strongest evidence pointing to US munitions as the source for the non-depleted uranium was its pattern of dispersal in the environment. A consistent pattern emerged at each bomb site: elevated levels of non-depleted uranium were discovered only in the immediate proximity to bomb craters and as distance from the craters increased, the concentration

of uranium in soil samples rapidly decreased. In Jalalabad, the local geology was the same for both the test subjects that tested positive for elevated levels of uranium in urine and the control subjects who displayed normal levels. The only difference between these two groups had been their proximity to targets destroyed by US weapons.

The one thing that is known with certainty is that a handful of subjects in Afghanistan who are sick have also tested positive for internal contamination of inordinately high levels of uranium. This picture is consistent with the small population of GIs suffering from Gulf War Syndrome who have similarly tested positive for internal contamination with depleted uranium. These known facts are suggestive that uranium is the causative factor in these documented illnesses. Scientific research free of political bias is warranted. The fact that such research has not been adequately undertaken by the government of the United States is itself damning. The failure to sponsor well-designed studies of uranium contamination amongst the available cohort of ailing Gulf War veterans is serving to conceal the truth. As long as that truth remains hidden, the United States can continue to proclaim that uranium weapons are harmless while spewing, with abandon, radioactivity over the face of the Earth.

Since no evidence has been produced to prove the contrary, a viable working hypothesis is that the non-depleted uranium found to be contaminating areas of Afghanistan was produced by US weapons. The question that remains unanswered is why? What advantage does the US derive by replacing depleted uranium in its munitions with natural uranium?

One diabolical advantage of weaponized natural uranium over depleted uranium is that its contamination of people and the environment can be carried out invisibly. Natural uranium leaves no unique signature as does depleted uranium. There is no way to distinguish the uranium naturally present in the body and in the environment from that produced from weapons. Charges that populations have been contaminated by munitions can be countered with the rationalization that the uranium found within their bodies is from ingestion/inhalation/absorption of naturally occurring uranium in food, water and soil. Given this fact, the bombing of Afghanistan with weapons containing non-depleted uranium can be seen as yet another human radiation experiment, designed to test what happens when natural uranium is used as a weapon of war.

This explanation is not at all far-fetched. The United States introduced depleted uranium into combat not only because of its destructive capability but to test the waters to see if it could get away with using radioactive weapons in warfare. The shortcomings of depleted uranium quickly became apparent. The DU used in Iraq, Bosnia and Kosovo was

recycled waste from nuclear reactors. The presence of uranium-236 in urine specimens and soil samples made this fact indisputable. The discovery in Kosovo of traces of plutonium and americium isotopes further confirmed that the DU used there had been cycled through a nuclear reactor. It is likely that uranium from this source was chosen for the manufacture of munitions due to huge existing inventories and its low cost. But the United States paid dearly for this choice. Depleted uranium munitions created a maelstrom of controversy throughout the world. The internet is flooded with articles in every language condemning the US for the use of these armaments. In addition, the standing of the United States within NATO suffered a severe blow when US allies learned that the depleted uranium that was contaminating and sickening their own troops in Kosovo was also tainted with plutonium.

The worldwide outcry against depleted uranium weapons was something the United States government seemed prepared to weather. But any plan the Pentagon may have harbored of continuing to use DU with impunity was forever ruined by the UMRC's research protocol that enabled the victims of DU contamination to be identified. The ratio of uranium isotopes in depleted uranium is unique. Its presence in biological and environmental samples leaves an unmistakable signature. By the means of mass spectrometry, the relative concentration of uranium isotopes can be ascertained and the presence or absence of DU can be confirmed. Thus, scientific researchers can follow in the wake of advancing armies and document which areas are contaminated with depleted uranium and who are its victims. War crimes that are so easily detectable cannot long endure.

Research at UMRC is continuing. Currently, efforts are underway to devise a methodology for estimating the total amount of depleted uranium in the body by the rate of its excretion in the urine. This would allow scientists to estimate retrospectively the total amount of DU initially gaining entrance into the body at the time of exposure. This groundbreaking work is setting a new course for research into the biological effects of DU contamination. Being able to identify victims of contamination as well as the level of exposure, future researchers will be able to uncover correlations between levels of exposure and observable health effects, thereby helping to establish whether DU plays a role in Gulf War Syndrome. This line of research may eventually damn the continued use of depleted uranium in combat. However, in the same stroke, it would mean that non-depleted uranium becomes the metal of choice in the next generation of munitions.

To demonstrate the deceptions that might be crafted to cover up the use of non-depleted uranium in a war zone, the UMRC field team proposed two scenarios that the US government might use to explain away the contamination in test subjects and environmental samples. One, the contamination resulted from the acquisition by Osama Bin Ladin and

Al Qaeda of natural uranium for the development of a nuclear weapon or a uranium dispersion bomb. Two, the Soviets, when retreating from Afghanistan, intentionally contaminated the soil with uranium as a punishment to the population. Such thought experiments serve an important function. They illustrate the possibility that propaganda can be fabricated to explain away environmental contamination produced by US munitions and the difficulty of verifying the truth of such assertions without extensive scientific investigation.

The use of natural uranium in weapons of war is more insidious than the use of depleted uranium. Its use represents a brilliant stratagem of deception. It can be used to contaminate people and make them ill, degrade the environment, poison soil and water, and yet its presence on the battlefield can be accounted for by laying blame at the enemy's door. It is a perfect method of radiological warfare.

10

Lebanon: The Reemergence of the Banality of Evil

Springing from the interminable entanglement of unappeasable neighbors, cross-border skirmishes between Hezbollah paramilitary forces and the Israeli army provoked a war in Lebanon in 2006. Between the beginning of the war on July 12 and the declared ceasefire on August 14, the Israeli military pummeled the Lebanese civilian infrastructure. The Israeli Air Force launched more than 7,000 air attacks on about 7,000 separate targets. From sea, the Israeli navy conducted an additional 2,500 bombardments. Dead amidst the rubble were 1,183 civilians, one third of whom were children (Amnesty International). An additional 4,054 people were injured and 970,000 Lebanese were displaced. Included in the 31 "vital points" which incurred severe damage were airports, ports, water and sewage treatment plants and electrical facilities. Other targets partially or completely destroyed included 80 bridges, 94 roads, 25 fuel stations, two hospitals, 900 commercial enterprises and 30,000 residential properties, offices and shops (Amnesty International). After the conflict, the signature of uranium weapons was discovered in the dust.

The United States and Britain have claimed that the only weapons in their arsenals which contain uranium are antitank ammunition. This limited admission has put political constraints on the scientific investigations carried out by the United Nations Environmental Program. As observed by Dai Williams: "Previous UN Environment Program (UNEP) investigations into uranium contamination have been tightly restricted to weapons admitted by US and UK forces (i.e., antitank ammunition) and to targets approved by them" (Williams 2006a). Hemmed in by political ideology, the science of UNEP has been compromised. According to Williams:

> Soon after the Belgrade bombing in April 1999, there were reports of a major increase in airborne radiation in northern Greece and of uranium dust in Hungary. Several Spanish and Italian troops died a few months after working in heavily bombed areas in Kosovo. But the UNEP study of depleted uranium targets in the Balkans (2001) indicated that radiation was limited to a few meters. The UNEP study was delayed 16 months. Locations were tightly controlled by NATO and had been cleared before UNEP inspectors were allowed access.

The reliability of UNEP science came into question once again after they published the results of their research in Lebanon, conducted soon after the ceasefire.

The first indication that Israeli forces may have used uranium weapons occurred in September 2006 when Dr. Khobeissi of the Lebanese National Council for Scientific Research publicized his measurements of the elevated levels of radioactivity inside a crater in the town of Khiam (Busby and Williams 2007). Later in September, at the suggestion of Green Audit[1], Dai Williams undertook a self-financed field trip to investigate the destruction and environmental pollution produced by the war. Williams, a psychologist, has devoted a great deal of time to investigating and writing about the suspected use of uranium in modern weapon systems. His meticulous field report, filled with photographs and diagrams, is available on the internet under the title *Eos Weapons Study in Lebanon, September 2006 — Interim Report*.

While in Lebanon, Williams collected several soil samples from a number of craters that were produced by Israeli bombs. Included in the collection was a piece of impacted red clay which had been thrown onto a nearby balcony by an explosion that produced a crater in Khiam. While at the Khiam site, Williams recorded a video of Dr. Khobeissi taking a gamma reading of 725 nSv/hr inside this crater. The background readings in the area around the crater measured 30 nSv/hr.

Back in the UK, the sample was examined by a representative of Green Audit using

[1] The home of Green Audit is Aberystwyth, Wales, UK. Their mission statement as it appears on their website reads as follows:
"Green Audit was founded in 1992 as an environmental consultancy and review organization with the aim of monitoring the performance of companies and organizations whose activities might threaten the environment and the health of citizens. Democratic values are threatened when information is kept from the public and all routes of access are controlled. The aim of Green Audit is to give citizens the information they need to be able to question the companies which are destroying the environment we all depend on. It was worrying recognition that such information is presently suppressed and restricted which provided the impetus for the founding of Green Audit."

a scintillation counter and CR39 alpha-tracking plastic (Busby and Williams 2006a). Measurements revealed both alpha and beta radiation to be above background levels. This finding prompted the researchers to forward a portion of the sample, plus a second sample from a similar crater in Taire that did not show elevated radioactivity, to Harwell Scientifics at the Harwell Campus of the United Kingdom Atomic Energy Authority in Oxfordshire. There the samples were analyzed by inductively coupled plasma mass spectroscopy.

Of the uranium found in nature and natural/non-depleted uranium, the relative concentration by mass of the three isotopes are as follows: uranium-238 (99.274%), uranium-235 (0.720%), and uranium-234 (0.0055%). Applying a little math to these number, one discovers that the ratio of 238/235 equals 137.88. According to Busby and Williams: "The normal environmental uranium isotope ratio is 137.88 with a standard deviation of about 0.5 so values above 139 or below 136 are extremely unlikely" (Busby and Williams 2006b). A 238/235 ratio of 137.88 derived from analysis of a soil sample or a urine sample is a signature for the uranium found in nature. The ratio changes for depleted uranium. The relative concentration of uranium-235 is reduced and that of uranium-238 is slightly increased. Taking our math lesson a little further, if the numerator is increased and the denominator is decreased, the ratio of 238/235 will be greater than 137.88. Such a number will signify the presence of depleted uranium. Likewise, with enriched uranium the relative concentration of uranium-235 is increased and that of uranium-238 is decreased. The ratio will be less than 137.88.

When Harwell Scientifics analyzed the sample from Khiam, the result was unambiguous and surprising. The 238/235 ratio was 108, signifying **enriched uranium**. Further, the measurement of total uranium in the sample (mg uranium / kg of soil) exceeded background concentrations and the activity of total uranium was 182 Bq/kg. By contrast, normal activity of uranium in soil is between 5 and 20 Bq/kg (Busby and Williams 2006a). The location of the uranium within the sample was also significant. According to Busby and Williams: "The uranium was located in a fine surface deposit of black dust. This implied that it was the bomb itself which had generated the dust, i.e., that the EU was part of the bomb" (Busby and Williams 2006b). At a later time, a portion of the same sample collected at the Khiam crater was sent to the radiochemical laboratory of the School of Ocean Sciences at the University of Wales, Bangor. By means of a different analytic technique using alpha spectrometry, this testing confirmed excessive quantities of total uranium and an isotopic ratio of 238/235 of 117, again pointing to the presence of enriched uranium. Analysis of the sample with a gamma spectrometer gave puzzling results. The activity of uranium-234 within the sample was substantially greater than that from uranium-238. The uranium-234 was disintegrating at a rate of 235 ± 15 Bq/kg while the uranium-238 was disintegrating at 146 ± 8 Bq/kg. (In natural uranium, the activity of the two

isotopes in a sample is the same). Dr. David Assinder, who carried out the analysis, had this to say:

> The 238/235U isotope ratio and the enhanced presence of 234U relative to 238U are unusual for environmental materials. I'm not particularly used to seeing this type of ratio but I think these results would seem to indicate enriched U. My values differ, but not by that much, from Harwell perhaps due to the incorporation of some of the underlying soil when removing the black surface layer plus inherent variability in the deposit (Busby and Williams 2006b).

While in Lebanon, Williams also acquired the air filter from an ambulance which had been operating in south Beirut until it was rendered unusable two weeks after the commencement of the Israeli bombing campaign. The filter was brought back to the UK, and one quarter of it was sent to Harwell for analysis. Again, enriched uranium was detected. Three samples taken from the filter returned a 238/235 ratio of 113, 123 and 133 respectively (Busby and Williams 2006b). That enriched uranium turned up in more than one location, and in downtown Beirut, is significant. Here was evidence that the finding in Khiam was not an anomaly and that weapons fabricated with enriched uranium had been used in populated areas where its inhalation by humans was inevitable. The following observation by Busby and Williams drives this point home: "We should note that the intake by the vehicle can be used as a crude model for respiration of this material by humans and animals."

Evidence of enriched uranium had already been found in another war zone. Ted Weyman, who led UMRC's field research in Iraq in 2003, reported that a urine specimen taken from an Iraqi civilian tested positive for enriched uranium:

> A biological sample taken from one Al Basra citizen, who was exposed to the urban bombing campaign in that city, has an unusual composition of isotopes showing an enriched, as opposed to a depleted or natural, ratio of 235U/238U. The enriched uranium was found in a person exposed to and living adjacent to the same battlefield led by the British Desert Rats, south of Al Basra (Weyman 2004).

As in all good mysteries, the plot thickens. In the aftermath of the July War, the United Nations Environmental Program dispatched a field team to Lebanon to investigate the war's impact. They investigated numerous sites and collected a substantial number of soil and water samples. Due to the controversial finding at the Khiam crater, they made a special point of visiting the site. By the time of their arrival, the crater had been filled in.

On their request, the crater was dug out and environmental samples were gathered from inside the crater. In the final report of their investigation, entitled *Lebanon: Post-Conflict Environmental Assessment*, they describe their investigation of the area of the Khiam crater:

> The on-site dose rate measurements were higher than other assessed sites (where readings were usually 20 nSv/h), but were not alarming or outside the natural Lebanese range-laying readings of up to 80 nSv/h. No residue showing a higher radioactive reading was found during an in-depth investigation of the site. Three smear samples and one soil sample were taken at the site for detailed analysis. The laboratory analysis confirmed the higher natural uranium levels present at the site.
>
> The analysis of the soil sample showed 26.2 ± 0.7 [mg 238U/kg] with an isotope ratio 235U/238U of 0.00722 ± 0.00001, signifying that uranium with a natural isotope composition was found and that the natural uranium content in the area **(a localized zone of about 100 x 100 m)** [emphasis added], was higher than average by a factor of about 10. This value could not *a priori* be linked to the missile/bomb used to destroy the building and further detailed examination of the impact site was considered necessary to identify the source. The smear samples taken from the area showed neither DU, nor enriched uranium, nor a higher than natural uranium content. In addition to the nuclear mass-spectrometric investigation, samples were screened for other metals, including heavy metals. No exceptional results were obtained.

UNEP broadcast this verdict to the world as follows:

> **The analysis results show no evidence of the use of DU-containing penetrators or metal products. In addition, no DU shrapnel or other radioactive residue was found at the sites investigated. The analysis of all smear samples taken did not detect DU, enriched uranium, or higher than natural uranium content. After an extensive investigation, including of sites rumored to have been hit by DU weapons, it can be stated that the 'bunker buster' ammunition used by the IDF in the conflict did not contain DU, natural uranium or any other uranium isotope** [emphasis added].

When your integrity, reputation and scientific acumen are impugned, you rebut.

And this is exactly what Busby and Williams did in "On the UNEP and Green Audit Measurements of Uranium in Water and Soil Samples in Lebanon." As revealed in this paper, Williams made a second field trip to Lebanon to gather additional environmental samples. On November 20, he revisited the Khiam crater at the same time, coincidentally, that the UNEP team was there undertaking their investigation. While in discussion with them, Williams collected two water samples, one from inside the Khiam crater and one from the surface of another crater across the street which had been filled in. UNEP gathered water samples from the same locations. The collection of the water sample within the Khiam crater is worth noting. According to Busby and Williams (2007):

> The water was seen to be seeping back into the hole once the infill was removed. UNEP took a sample from the same place at the same time; in fact Green Audit's sample was taken by a UNEP technician and handed to Dai Williams.

Quite clearly, the two water samples were identical. Yet, the lab results were contradictory. The UNEP samples were analyzed at the Spietz laboratory in Switzerland and the samples collected by Williams were analyzed at Harwell. The authors describe the conflicting results in this way:

> Harwell conducted two determinations on each of the Green Audit samples from the two craters. For concentrations of total uranium the results largely agree with the UNEP Khiam water result; Spietz (UNEP) gives 5300 ng/l, while Harwell (Green Audit) gives between 6400 ng/l and 4000 ng/l. However, whilst Harwell gives isotopic ratios of 102 to 109, indicating a significant excess of U235 (enriched uranium), the Spietz result for their single sample was given as 140.6 (a nonsignificant deficit of U235). This anomaly is extraordinary, given the accuracy of the instruments used by the two laboratories. The discrepancy remains to be explained.

Busby and Williams offer only one possible explanation for this discrepancy:

> We can only conclude that the Spietz analysis of the UNEP water sample does not correspond to the sample they gave to Dai Williams. The only difference apparent is that Spietz filtered the water samples (the filter pore size is not given) while Harwell did not. Therefore if there were enriched Uranium in large particles which did not pass the Spietz filtration this might conceivably explain the discrepancy.

As with the water samples, a discrepancy emerged in the test results of soil samples

collected by Williams and UNEP. On his second trip, Williams gathered a number of samples from the area of the Khiam crater. Two of these had been analyzed at the time of the writing of the rebuttal to UNEP's findings. These samples were taken in immediate proximity to where the water samples had been gathered by both Williams and UNEP. The results this time were perplexing. The soil sample from the first crater, which had been filled and then reexcavated, demonstrated an isotopic signature of natural uranium. But the total concentration of uranium in the sample was uncharacteristically high. The second sample from across the street also gave high levels for total uranium, but two separate determinations by Harwell of the 238/235 ratio yielded contradictory results: 125 (enriched uranium) and 161 (depleted uranium). Harwell offered no explanation for this discrepancy. Explaining the differences between the water and soil sample, Busby and Williams commented:

> It is hard to explain the existence of enriched uranium in water inside a crater where the soil samples above the water show natural uranium. It may be relevant that when Dai Williams arrived at the crater in November, it had been filled in with rubble and soil and had to be re-excavated to obtain samples. It was the soil material that had been excavated that tested for natural uranium, whilst the groundwater that seeped back into the freshly excavated pit tested for enriched uranium.

The soil samples gathered by UNEP and Williams were similar in one respect. An uncharacteristically high level of radioactivity was present. Measurements ranged between 160 and 600 Bq/kg. By contrast, the activity of limestone which forms the base geology of the area of southern Lebanon is 16 Bq/kg. According to the US National Council for Radiological Protection, the activity of uranium in rock ranges from 7 to 60 Bq/kg, with a mean in carbonate rock of 25 Bq/kg (Eisenbud and Gesell; Busby and Williams 2007). Nevertheless, UNEP opted to ignore the anomaly with this blanket statement: "Concentrations of uranium are elevated but have a natural composition and originate from the region."

Busby and Williams uncovered a disturbing misrepresentation in the measurements made by UNEP. In UNEP's *Lebanon: Post-Conflict Environmental Assessment*, the statement is made that ***the*** soil sample from the Khiam crater showed a concentration of uranium of 26.2 ± 0.7 [mg 238U/kg]. However, examination of UNEP's numbers for the nine samples at Khiam reveal no such number (UNEP 2007 Data Test Reports; Busby and Williams 2007). So where did this number come from? If the concentration of uranium in the nine soil samples are **averaged**, the identical number materializes: 26.2. But wait a second. This number is meant to represent the concentration of uranium **in** the Khiam crater. In

actuality, it is an average of nine samples collected within an area of 70 meters of the crater. At best, this is misleading. Busby and Williams make the point this way:

> On p.151 of the report, UNEP, referring specifically to the Khiam crater, states 'the analysis of the soil sample showed 26.2 ±0.7 mg U238/kg with an isotope ratio U235/U238 of 0.00722 ±0.00001.' This isotope ratio represents a U238/U235 ratio of 138.5 and would be considered natural uranium. The concentration is very high however — about 325 Bq/kg. The point is that no such sample was reported in UNEP's Khiam soil sample results published on 15 January and given in Table 2 [of Busby and Williams 2007]. Table 2 results include measurements from within 70 m of the crater, not measurements solely from within the Khiam crater. Yet it is easy to see that the figure of 26.2 is exactly the mean of the nine measurements presented in Table 2. This extraordinarily improbable coincidence is clear evidence of misdirection, spin and untruth. Let us be clear; UNEP's report is presenting as the measure of soil uranium content in the Khiam crater the mean value of nine readings of soil uranium taken from up to 70 meters away. This is a serious matter and should be investigated. UNEP's own soil data provides clear evidence of high levels of uranium directly associated with the crater.

If one looks at the soil samples of Khiam, soil sample 8 contained 52.4 mg of uranium-238 per kilogram of soil with an activity of 650 Bq/kg. By comparison, soil sample 3 had 3.5 mg of uranium-238 per kilogram of soil and an activity of 43 Bq/kg. In the process of averaging the results, UNEP published misleading numbers to create the perception that the concentration of uranium and its radioactivity in the Khiam crater was less than what had actually been measured.

To date, no analysis of soil or water samples from Lebanon has been published indicating whether or not uranium-236 was present. If uranium-236 is eventually detected, it will be an unmistakable signature of bomb debris, since uranium-236 does not naturally occur in the environment. UMRC discovered elevated levels of uranium with an isotopic signature of natural uranium in Afghanistan which was accompanied by the presence of uranium-236. This was also discovered in areas bombed in Iraq during the second Gulf War. Could the same type of weapon or a weapon made with the same species of uranium have been used in Lebanon?

UNEP concluded that the uranium around the crater at Khiam was uranium naturally present in the soil. Critics of UMRC's work in Afghanistan have presented the same argument. The elevated levels of natural uranium in soil samples from bomb craters and

in the urine of civilians exposed to bomb debris is from uranium naturally present in the environment. Weapons containing uranium are not being used. Period!

The similarities between the test results of samples retrieved respectively from Afghanistan and Lebanon should not be lost on the reader. Only two possible explanations exist: (1) Precision bombing has become so accurate in recent wars that bombs are only dropped on sites where elevated concentrations of naturally occurring uranium are present in the soil. (2) The bombs are putting that uranium into the soil and creating areas with anomalously high levels of "natural" uranium.

The types of weapons being used in recent conflicts and their composition are classified information. Under these circumstances, seekers of truth have been forced to become detectives. By applying modern forensic techniques on material gathered at bomb sites, they are unearthing war crimes. The evidence gathered to date by these sleuths tells the tale of an ongoing crime spree that continues to evolve with ever-increasing sophistication.

During the First Gulf War, the United States introduced DU weapons into battle. The value of these munitions for destroying enemy armored vehicles was extraordinary. However, their long-term usefulness was threatened by the international outrage that arose over the issue of the US contaminating civilians, their own military personnel and the environment with radioactivity. For a time, such criticism was easily deflected because there was no way of identifying who, if anyone, was actually internalizing DU. As clever as this simple evasive tactic seemed to be, it was short-lived. Within 10 years, a diagnostic test was developed for detecting internal contamination with depleted uranium. As a result of this advance, the US could no longer cover up its nefarious activities. Further complications arose for the United States in the aftermath of the war in Kosovo, when it became public knowledge that its depleted uranium stockpile was laced with transuranics, and that enemies and allies alike were being contaminated with plutonium. This outrage, voiced by NATO allies no less, forced a change in bomb composition. Heaven forbid that the US would give up a cherished weapon system. Rather, it set about redesigning uranium weapons with the aim of making their use more difficult to detect.

During the war in Afghanistan, the profile of the crimes being committed began to change. Soil samples from the handful of craters and urine samples taken from people living nearby delivered no signature for depleted uranium. What was instead discovered were elevated levels of natural uranium with a detectable presence of uranium-236. The same was discovered in Iraq in 2003. This change in *modus operandi* was brilliant. No telltale presence of transuranics could be found, and the uranium detected in both environmental and biological samples appeared to be naturally occurring uranium. With bombs fabricated

from natural uranium, the argument could always be made that the uranium was present in the environment long before any bombing occurred. By creating just this little seed of doubt in the minds of inquirers as to the source of the "natural" uranium, the US and/or Israel may be acquitted from all accusations of wrongdoing.

Is there any difference between terrorists and those who disperse uranium in populated areas? The findings in Lebanon confirm that the uranium-terrorists are deploying a secret hybrid of uranium in their weapons. The collateral damage to the health of the surrounding population cannot be assessed because the composition of the material being scattered into their lungs is unknown. Samples retrieved from Lebanon provide clues to the crime. They await a modern Sherlock Holmes to decipher the mystery.

Clue # 1: The crime scene in Lebanon yielded evidence of enriched uranium. In the uranium found in nature and purified natural uranium, the relative concentration by mass of uranium-235 is 0.72 %. The measurements of the ratio of 238/235 in the samples retrieved in Lebanon were 117 and 108. These numbers translate into a concentration of uranium-235 between 0.85 and 0.93 %. These numbers are curious. They indicate unmistakably that the uranium had been enriched but ever so slightly. Before being deposited in the streets of Khiam, this uranium had likely fueled a nuclear reactor. There is no way that it could be uranium naturally occurring in the environment. It was deposited in Lebanon by human activity. Let it be known "depleted uranium" weapons have been made obsolete. A new generation of uranium weapons is being fielded whose radioactivity is not depleted at all, but rather enhanced above that of "natural" uranium.

Clue # 2: The activity of uranium detected in environmental samples from bomb sites, measured in disintegrations per kilogram (Bq/kg), was significantly elevated above that of samples collected from nearby areas.

Clue # 3: The detected activity of uranium-234 was significantly greater than the activity of uranium-238. In one sample, the activity of uranium-234 was 235 ± 15 Bq/kg, while the activity of uranium-238 in the sample was 146 ± 8 Bq/kg (Busby and Williams 2006b). In natural uranium, the two isotopes decay at the same rate. The detected increase in the activity of uranium-234 must have come from an elevated increase in its relative concentration above that found in natural uranium. Since uranium-234 follows uranium-235 during the process of enrichment, this provides further evidence that the uranium had been doctored in an enrichment facility.

What the hell are the weaponeers up to? Given the lack of transparency into their machinations, those researching the use of uranium in modern weapon systems have gen-

erated a number of hypotheses. One idea suggested by Busby and Williams (2006b, 2007) is that enriched uranium is somehow intentionally being deposited along with depleted uranium weapons in order to locally increase the presence of uranium-235, thereby creating an environmental signature of natural uranium. In the absence of careful isotope analysis, the argument can be fielded that elevated levels of uranium are natural to the area and not a sign that uranium weapons produced the contamination. Another line of speculation is that the enriched uranium found in Lebanon was the remnant of a new experimental weapon, either a small nuclear fission device or a miniature deuterium cold fusion neutron weapon. A third guess is that the enriched uranium was from a weapon dependent on the high temperatures of a uranium oxidation flash (Busby and Williams 2006a). Busby and Williams speculate as follows: "One possibility is that uranium is being used as the 'reactive metal' in the new SFAE's (Solid Fuel Air Explosives) used in the new generation of thermobaric weapons deployed by US forces since February 2002 and witnessed during IDF attacks in Lebanon."

Writing in *The Independent* in the UK, Chris Bellamy, a professor of military science and doctrine at Cranfield University, had this to say upon hearing that enriched uranium had been found in Lebanon:

> The Khiam sample, with 108 parts U-238 to one of U-235 — just under one percent — is clearly enriched — but not much. So, in the absence of any palpable military advantage, in terms of its mass and its ability to generate heat and fire compared with DU or natural uranium, why was this enigmatic material used? There are several possibilities. The first is that there was a simple mistake — that uranium with an elevated U-235 content was used instead of DU or natural uranium. The Khiam sample was very small — 25 grams. Contamination with soil could easily obscure a higher degree of enrichment. Spent nuclear fuel — after the power has been generated — typically contains 2.5 percent U-235, but it can be as low as 1.5 percent — close to the Khiam sample level. So the uranium in the Khiam projectile could just have been spent nuclear fuel.
>
> One way to dispose of enriched uranium safely is to blend it with natural uranium, in such a way that the U-235 is extremely difficult to re-extract. That might well produce a substance with just under one percent U-235, which was a component of the Israeli Khiam bomb.
>
> It is also uncertain whether the munition was made in the US or by the Israelis themselves. If the Israelis or the Americans want to avoid

> accusations, at the very least, of a cavalier attitude to the use of nuclear waste products, they need to explain what was in that bomb and why it was there (Bellamy).

Although the traces of uranium recovered in Lebanon may be the remains of an exotic new weapon, the truth is likely to be more humdrum and pedestrian. As Bellamy suggests, the uranium may have been acquired from the reprocessing of spent reactor fuel. Or it may have been a product of the downblending of enriched uranium from nuclear weapons or reactors, produced by diluting enriched uranium with depleted uranium. The reenrichment of depleted uranium is a third alternative. In Russia, and perhaps elsewhere, a portion of that nation's enrichment capacity is currently being used to recover the uranium-235 in depleted uranium, concentrating it into a product that resembles natural uranium.

What the Lebanon samples suggest is that some hybrid of uranium has been incorporated into the arsenals of the United States and Israel. Although kept secret from the public, a few hallmarks of this unknown species of uranium can be surmised. It is plentiful, useless for most other types of applications, and cheap. This is the point where the banality of evil reemerges. The enriched uranium deposited among the Lebanese may be nothing more than a product of market forces and business as usual. Reprocessing facilities are acquiring some species of waste from nuclear weapons or reactors and modifying it to produce a metal with a profile approaching that of natural uranium, so meeting the specifications of the military. Sold to weapons manufacturers on the cheap, it is incorporated into weapons which are then used to destroy the lives of people on the other side of the world. The fact that the environment is being contaminated and people are being sickened by a species of uranium more radioactive than natural uranium is just an unfortunate side effect produced by the economics of the marketplace.

Among those who study uranium weapons, the assumption is commonly held that weapon manufacturers acquire their uranium from the huge stockpile of DU held in the United States. This assumption may be fallacious. Largely in the shadows, a worldwide marketplace of buyers and sellers of uranium is in operation. Perhaps a broker serving the uranium market, upon receiving a contract from a weapon manufacturer, scoured the world for a seller that could fill the contract at the cheapest price. Under this scenario, uranium from reprocessing facilities from around the globe may end up in the arsenal of the United States military. Depleted uranium. Natural uranium. Enriched uranium. As long as the ratio of isotopes falls within specified parameters established by the nation's weapons laboratories, who the hell cares. Perhaps the explanation for the different species of uranium found on battlefields around the globe is not any more complicated than this.

The banality of evil, as it applies to the dumping of uranium on fellow human beings, has another dimension that is rarely considered. Do the generals that plan the wars and the operation analysts who design bombing campaigns have any knowledge of health physics and uranium toxicology? Do they have any concept of what they're doing and the effects they're having on the health of the surrounding population? Is the pilot who drops a uranium bunker-buster in the midst of Baghdad or Beirut versed in the varying radiosensitivity of different cell lines within the body and their increased vulnerability at different stages within the cell cycle? Do those who work in the munitions factories keep abreast of the latest research on the impact of uranium on cell physiology? What about the Commander-In-Chief who authorizes a war or the members of Congress who allot funds to the Department of Defense for the procurement of weapons? Who among them is cognizant of the synergistic effects in the human body between uranium's radioactivity and its biochemistry? Somewhere in the archives of one of the nation's weapon laboratories, a middle-management trainee may have written a paper on the human and environmental effects of uranium weapons and then filed it away. Somewhere this knowledge exists. But it doesn't trickle up to those responsible for contaminating populations with heavy-metal alpha emitters.

In ignorance of the consequences of their deeds, an entire society is blindly perpetrating crimes against humanity. Nobody knows what they're doing, yet everyone marches in step.

11

Port Hope

The huge power-generating windmill is impossible to miss. Driving into Toronto from the west along the shore of Lake Ontario, this monument to alternative energy dominates the landscape. Its silent majesty cannot help but impress itself upon all who pass by. Spinning calmly above the traffic jams of the megalopolis, it helps to remind harried commuters of a prime feature of the Canadian identity: communion with the outdoors, pristine nature to the north, summers at the cottage, and the endless expanse of old growth forests, unpolluted lakes and untamed wildlife. The maple leaf adorning the nation's flag taps into that same place of the Canadian consciousness. But hidden out of sight of that windmill are Ontario's 18 operating nuclear power plants. And lurking beneath that maple leaf is a radiation hazard symbol.

Little known to the general public, peace-professing Canada has played a major role in the proliferation of nuclear weapons throughout the world (Edwards 1983). It has routinely sold uranium to countries with nuclear weapons programs and supplied other countries with Candu reactor technology, providing them with essential elements for the development of nuclear weapons. It was Canada that sold reactors and uranium to India, facilitating that nation's detonation of a nuclear weapon in 1975.

Canada's role in the nuclear age sprang from humble beginnings. In 1930, while prospecting along the eastern shore of Great Bear Lake in the Northwest Territories, Gilbert LaBine unearthed a vein of ore containing silver and pitchblende (Edwards 1998). The ore was of extremely high grade. Early samples were assayed at between 27.88 and 83.90 percent uranium oxide, with an expected radium content of between 70.79 and

213 milligrams per ton (Bothwell). This discovery gave birth to the Eldorado Mine, operated by Eldorado Gold Mines Ltd. The settlement that grew up around the mine became known as Port Radium. LaBine and his backers anticipated a financial windfall from the discovery. Due to its scarcity, radium was highly prized and extremely valuable. The price of a *gram* of radium at the time of LaBine's discovery was $70,000. Medical facilities used radium for the treatment of cancer. In addition, a lucrative industry had grown up using radium to produce glow-in-the-dark paint for meters, gauges and timepieces. In 1924, Belgium had driven other radium producers out of the market and the only available source of radium in the world was the Belgian Congo.

The Eldorado mine was worked by men of the aboriginal Sahtugot'ine, the Dene First Nation of Sahtu (Great Bear Lake). Tribal members also worked as porters, loading by hand the dusty, radioactive ore into burlap bags, transporting the bags down to the shore and then loading them onto boats. The men would accompany the ore across the lake and then unload the bags onto trucks at the rapids at Bear River which transported the ore along the portage. The men would then load the ore onto barges which were then towed to the Mackenzie River, then up the Mackenzie to Great Slave Lake, and then along the Peace River into Alberta. At the Fort McMurray railhead, the ore was loaded onto trains for the journey east across the country. At every step along this route, when the bags of ore were unloaded then reloaded, radioactive dust would shake loose from the bags, covering the porters and entering into their lungs as they breathed. At no time were these workers informed of the hazards to which they were being continually exposed. Publications of the day issued by the Canadian government warned of serious health hazards from chronic exposure to even minute quantities of dust from high-grade radioactive ore, in particular the ores from Great Bear Lake (Edwards). By the early 1960s, the hazard courted by the aboriginal tribesmen, derogatorily referred to as "coolies," was depressingly apparent. The men began dying of diseases previously unknown to their people: cancers of the lung, colon and kidney (Peterson). The devastation to the Sahtugot'ine was aptly summarized in 1998 by tribal member Cindy Kenny-Gilday:

> Deline is practically a village of widows, most of the men who worked as laborers have died of some form of cancer. The widows, who are traditional women, were left to raise their families with no breadwinners, supporters. They were left to depend on welfare and other young men for their traditional food source. This village of young men are the first generation of men in the history of Dene on this lake to grow up without guidance from their grandfathers, fathers and uncles. This cultural, economic, spiritual, emotional deprivation impact on the community is a threat to the survival of the one and only tribe on Great Bear Lake (Peterson).

The final destination of the pitchblende mined at Port Radium was Port Hope, a sleepy little town 100 kilometers east of Toronto on the shore of Lake Ontario. There, a refinery chemically processed the pitchblende, extracting its radium content. On average, approximately 0.14 grams of radium was recovered from each ton of pitchblende. As a consequence, thousands of tons of uranium-bearing waste, which contained the radioactive decay products of uranium, accumulated in and around the Port Hope facility. This discarded waste proved instrumental in kick-starting the Manhattan Project. During the early months of 1941, Dr. Lyman J. Briggs, chairman of Roosevelt's Advisory Committee on Uranium, ordered eight tons of refined uranium oxide from Eldorado Gold Mines Ltd (Edwards 1998). Upon receipt of the order, the Port Hope facility was converted to a uranium refinery and uranium was extracted from the residues scattered around the plant. This uranium was then shipped to the Metallurgical Laboratory at the University of Chicago where it was used in the first atomic pile, proving that a sustained chain reaction was achievable.

As the 1930s came to a close, Belgium, intending to drive the Canadians out of the market, drastically sliced the price of radium. Unable to compete financially, Eldorado shut down its mining operations in 1940. Before closing, however, sufficient quantities of ore were mined to meet projected demand for the next five years and stockpiled at Port Radium (Edwards 1998). This uranium, too, ended up in the weapons program of the United States. In March 1942, Eldorado received an order from the US Army for 60 tons of uranium oxide. To fill this order, the mined ore lying on the shore of Great Bear Lake was concentrated and shipped east for refining. Miners were also flown in to Port Radium to reopen the mine and pump out the water that had flooded the mineshafts. In July, a second order was placed with Eldorado for an additional 350 tons. Then in December, 500 more tons were requisitioned before the previous orders had been delivered. To fill these contracts, freshly mined uranium was airlifted to Port Hope. Due to inadequacies in the refining process, the uranium exiting the refinery remained 4-5% impure (Bothwell). This uranium failed to meet the stringent demands of the Manhattan Project. As a consequence, the uranium was then shipped to Mallinckrodt Chemical Company in St. Louis, Missouri, for further purification. Using a unique extraction process, Mallinckrodt was able to achieve a level of purification on an industrial scale that was seldom achieved under laboratory conditions (Bothwell). By the end of 1942, a total of 220 tons or uranium oxide had been delivered to the United States. These 220 tons constituted the total amount of Canadian uranium used to build the bombs that destroyed Hiroshima and Nagasaki. The remaining uranium demanded by the war effort came from other sources.

As fate would have it, 1,200 tons of concentrated high-grade ore, containing up to 65% uranium oxide, originally mined in the Belgian Congo, was sitting in the Baker and

Williams warehouse on Staten Island.[1] The Belgian mining company, Union Minière, had imported the uranium into New York in 1939 with plans to extract its radium content. But due to the collapse of the market, it remained in storage. In September 1942, the US Army acquired this uranium and shipped it to Port Hope where its refining took priority over Canadian uranium. The Belgian ore had a higher uranium content and a different mineral composition which, when refined in Port Hope, resulted in a purer product than that produced from Canadian ore. As a consequence, further shipments of mined uranium from Canada to the US were interrupted until after the war. The remaining uranium needs of the Manhattan Project were fulfilled by ore from Belgium. By the end of the war, the Manhattan Engineering District had acquired 18.9 million pounds of uranium to build the first atomic bombs: Approximately 3.4 million pounds originated from the Colorado Plateau (a byproduct from the mining of vanadium), 2.2 million pounds came from Canada, and 13.3 million pounds came from the Belgian Congo (Edwards 1998). Much of this uranium ended up either passing through the enrichment cascades in Oak Ridge, Tennessee, to produce the highly enriched uranium for the Hiroshima bomb or fueling the nuclear reactors at Hanford, Washington, to produce the plutonium for the Trinity test and the bomb that destroyed Nagasaki (Edwards 1983).

In January 1944, C.D. Howe, the Canadian Minister of War, secretly nationalized Eldorado's Great Bear Lake mine and its refinery at Port Hope, making these holdings the property of the Canadian government. It henceforth operated under the name Eldorado Mining and Refining Ltd. Canada's contribution to nuclear weapon development did not stop with supplying and refining uranium. During the war, the Canadian government financed and built a secret laboratory in Montreal to research reactor designs, plutonium production and the chemical separation of plutonium from spent reactor fuel. It was here that a reactor was designed that used heavy water rather than graphite as a moderator. This research bore fruit with the design and construction of the Zero Energy Experimental Pile (ZEEP), Canada's first nuclear reactor. Built at Chalk River, Ontario, 150 miles northwest of Ottawa, the reactor began operation one month after Hiroshima on September 5, 1945. Plutonium produced in this reactor was sent to the United States for weapon production. A second heavy water reactor was designed at the Montreal lab that, in theory, would produce two to three times the amount of plutonium then being produced by the

[1] A fact sheet published by the US Department of Energy Office of Legacy Management provides this information: "During the 1940s, the Manhattan Engineer District used these warehouses for short-term storage of uranium concentrates produced in Port Hope,Canada, from African ores. Approximately 219,000 pounds of orange and yellow sodium uranate were delivered to the site in 1942, and in the following year, approximately 86,000 pounds of the same substance along with 22,000 pounds of sodium uranyl carbonate and 20,000 pounds of black uranium oxide were delivered. The uranium was later distributed to Manhattan Project facilities."

reactors operating at Hanford. The promise of this design was validated in 1947 when Chalk River's second reactor, the NRX, came into operation. Chalk River was also the site of a pilot plant for the separation of plutonium. Canada further assisted the United States by helping it acquire its own supply of heavy water from a plant operated by Consolidated Mining and Smelting in Trail, British Columbia.

After World War II, the United States continued to seek out large quantities of uranium to fuel its weapons program. As a consequence, Canada's uranium industry skyrocketed. Uranium mining continued in the Northwest Territories, and other mines began operating in northern Saskatchewan and in northern Ontario in the region of Elliot Lake. By 1959, 23 mines were in operation. That year, Canada exported 12,000 tons of uranium, securing a revenue of more than $300 million (Edwards 1983). Uranium was Canada's fourth most important export after wheat, hardwood and newsprint (Edwards 1983). Almost all of this uranium, plus the plutonium produced at Chalk River, was exported to the United States and United Kingdom for the production of nuclear weapons. As these countries developed alternative sources of uranium, Canada's export of uranium for the purpose of weapon development ceased. But Canada's participation during the 1940s and 1950s left behind a dirty legacy: 50 million tons of radioactive mine residues piled up at Great Bear Lake, Elliot Lake, Bancroft in Ontario and Uranium City in northwestern Saskatchewan (Edwards 1983).

When Canada stopped fueling weapon development, its export of uranium dropped precipitously. By 1965, only three mines were operating and total production was below 3,000 tons. A decade had to pass before uranium mining became lucrative once again. The new financial incentive was initiated by the establishment of an international uranium price-fixing cartel in 1972 that artificially manipulated a price increase (Edwards 1983). Later in the decade, the price was corrected by legitimate demand when nuclear power plants throughout the world came into operation. Today, Canada's uranium industry is robust. According to Natural Resources Canada, the country is the world's leading producer of uranium, supplying one-third of the total global output. Annual revenue from mining and milling hovers around $500 million. For this uranium to be used commercially, it first must undergo refining and conversion to products needed by the nuclear industry. Canada provides these services as well. This accounts for the ongoing importance of the Port Hope installation.[2]

Until 1983, all uranium refining in Canada took place exclusively at Port Hope.

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[2] Only three other companies provide uranium refining and conversion services to the western world: Honeywell in the United States, British Nuclear Fuels Limited in the UK and Comurhex in France.

Then a new intermediate refinery was built at Blind River, Ontario. That refinery receives uranium ore concentrates from Canadian mines and other producers from around the world, and refines it into uranium trioxide. That product is then shipped to Port Hope for further conversion to either uranium dioxide or uranium hexafluoride. (For uranium to be enriched, it must be in the chemical form of uranium hexafluoride.) The UF_6 plant at Port Hope was added to the installation in 1973. In 1988, Eldorado Mining and Refining Ltd was privatized, along with the Saskatchewan Mining Development Corporation, and became Cameco. Cameco currently operates the Port Hope refinery. It also operates Zircatec Precision Industries, with facilities in Port Hope and Cobourg, which produces fuel pellets from uranium dioxide and assembles fuel bundles for use in Candu reactors.

Today, many people in Port Hope live with a sense of disquiet. They suspect that, just by living in their town, they are exposing themselves to health hazards. Having been home to a radium/uranium refinery for over 70 years, Port Hope is a repository of vast quantities of chemical and radioactive wastes. Unfortunately for the public, little information is readily available as to the exact composition of these wastes and the hazards they represent. The problem is further compounded by the fact that limited data exists as to the exact types of activities the refinery has been involved in since its inception. When a researcher cobbles together the few clues available in the public domain, the picture that emerges is not reassuring. The ore from Great Bear Lake was of extremely high grade, and it is certain that the discarded residues of pitchblende around the refinery contained uranium-238 and uranium-235 and the radioactive products of their decay chains. Among the decay products of uranium-238 are thorium-230 and radium-226, which when it decays, becomes radon-222. High radon levels are a sign that numerous other radionuclides are present and simultaneously undergoing radioactive decay. On the positive side, most of these historic wastes are buried, albeit close to the surface, so there is at least somewhat of a barrier to human contamination. Groundwater is likely contaminated. Any ground-level waste resuspended in the air will present an inhalation hazard[3] In addition to the historic wastes buried around the town, it is known that the refinery has had a long history of releasing over 100 kilograms of fine particulate uranium into the air every year as a result of uranium processing. Further, in 2004, Tedd Weyman of UMRC measured neutron radiation along Cameco's property line which was being emitted from a UF_6 cylinder sitting on the back of a trailor in a parking lot (Harries). Known chemical contaminants produced by the plant include ammonia, fluorides, nitrates and arsenic (McNamara). Radionuclides, heavy metals, chemical contaminants and PCBs have been flushed into the harbor through storm

[3] Sitting on Centre Pier is a 15,000 cubic metre pile of contaminated soil excavated from the West Beach. During high winds in December 2004, tarps covering the pile blew off three times, scattering radioactive material over the town and into the lake (McNamara).

drains (McNamara). The Port Hope facility is also known to have produced depleted uranium metals before 1992, to have processed enriched uranium from 1966 to 1987 and to have blended enriched and depleted uranium powders to specific isotopic concentrations (Durakovic *et al*. 2007)

One subject that has received virtually no attention is the nature of the waste produced by the refining of the high-grade Belgian ore during World War II. Manhattan Project scientists discovered that, despite the best refining process at Port Hope, the uranium product was not sufficiently purified to meet the stringent demands of bomb building. Thus, the partially purified Belgian ore was sent to the Mallinckrodt Chemical Company for further refining. Today, the waste produced from that facility is stored in three silos at the former Fernald, Ohio, uranium production facility and in one silo in Lewiston, New York. This waste goes by the enigmatic name K-65. Wastes designated by this classification are the byproduct of the processing of uranium ore that contained between 35 to 60 percent U_3O_8. Of this waste, the Department of Energy published a study in 1994 which had this to say:

> * The K-65 residues are similar in activity and half-life to transuranic waste, which is regulated under 40 CFR Part 191.
>
> * The activity of Ra-226 in the K-65 residues is 100 to 100,000 times higher than that found in uranium mill tailings subject to 40 CFR 192.
>
> Disposal of these wastes in a deep geological repository is the only way to protect the public health and safety for a long period. The fact that the DOE does not currently have an operational high-level waste storage facility does not justify leaving these high activity residues at a site that does not meet the minimum requirements for protection of the public (DOE 1994).

In a 1993 letter from the State of New York Department of Environmental Conservation to Hazel O'Leary, then Secretary of Energy, the disposal of the K-65 wastes was addressed as follows: "the most applicable standards would be those of 40 CFR Part 191 requiring deep mine repository disposal and assurance of over 10,000 years of isolations from mankind" (DOE 1994). In *Safety of the High-Level Uranium Ore Residues at the Niagara Falls Storage Site, Lewiston, New York*, published in 1995 by the National Academy of Science's National Research Council, the K-65 residues were likened to high-level wastes (Commission).

Port Hope

The issue of proper disposal of K-65 waste is extremely relevant to the people living in Port Hope. The refinery processed the high-grade Belgian ore during the war and processed the high-grade ore from the Eldorado mine for decades. It is a virtual certainty that the wastes scattered around the town and in the harbor have a strong family resemblance to the historic K-65 wastes in the US.

Today, Port Hope is home to 16,000 people. It is also the home of 3.5 million cubic meters of radioactive residue scattered atop and beneath a thousand individual properties (McNamara). As described in *Port Hope: Canada's Nuclear Wasteland*, this quantity of waste "represents a pile the size of a football field, 2300 feet (700 m) high. It would fill 17,500 railway boxcars. This train of radioactive waste would be 424 kilometers long" (McNamara).[4] In the past, waste contaminated with radium and thorium series radionuclides was dumped into ravines, the waters of Lake Ontario at the city's harbor and at a number of other sites throughout the area. Tailings were made freely available to anyone willing to cart the material away. This practice continued until the mid-1960s. As a consequence, uranium waste, emitting radon gas, ended up being used as fill in Port Hope and surrounding communities, under roads, homes, yards, parks, schools and other public buildings, the local beach and the municipal landfill. Another disturbing dimension to the problems in Port Hope is the fact that no buffer zone exists between the refinery and surrounding neighborhoods. The town and the plant grew up together before anyone gave much thought to the idea that this was a potentially dangerous situation. During the mid-1970s, the Canadian government conducted studies to find a suitable site in Ontario for a facility to produce uranium hexafluoride. Eleven locations throughout the province were considered. Port Hope was excluded from consideration due to the fact that there was no way to incorporate the facility on the premises of the refinery and meet the criterion of having a 1,000 meter buffer zone as required by the Atomic Energy Control Board. When none of the study sites proved suitable, the Canadian Government contravened its own buffer zone requirement and gave the go-ahead for the UF_6 plant to be built in downtown Port Hope (McNamara).

The environmental monitoring of Port Hope that has been made public paints a disturbing picture. In 1966, Dr. D. G. Andrews, Professor Emeritus of Nuclear Engineering at the University of Toronto, investigated a number of sites around Port Hope and found numerous instances of unnatural levels of contamination. In a paper published in 1996, Andrews cited some of his findings 30 years earlier:

[4] An additional 872,000 cubic meters of waste is deposited immediately west of Port Hope at Welcome and Port Granby (McNamara).

> West drainage ditch from Welcome down to Shoreline: Clearly there was a steady flow of radioactive effluent leaching out and draining into the harbor. I commented that none should ever build a dump on a hill above a town! It was suicidal! Actually builders came and built a row of houses down to the lower level! In the 1976 crisis, the house basements were found to be high-radon and expensive remedial work had to be undertaken.
>
> East drainage ditch from Welcome down to Shoreline: The first thing I noted going down the hill was a cottage which had, at its door, a reading of 10 milliroentgen per hour exposure (about 80 rems per year or 80 times the allowable level). Here the later situation was even worse. Builders built a school. In 1975, its basement was found to have high radon too, starting a stampede. The town had known about the contamination, but had cleared the construction of the school regardless.
>
> Port Granby Dump: What was annoying was that trucks had carried wastes up to the dump and had left clots of radioactive material on the road measuring up to 30 milliroentgen per hour exposure (about 240 rem years or 240 times the allowable level). I recommended a change to cut and cover.
>
> The Refinery: I informed the AECB [Atomic Energy Control Board] that Eldorado should have a "buffer zone." There were houses less than 50 yards from the plant showing one milliroentgen per hour exposure (about 8 rems per year or 8 times the allowable level).
>
> Other Contamination: The lower town streets, the loading bay, the local bathing beach, the water in the harbor and samples from the harbor mud showed radioactivity. Samples from farms on the hilltop also showed radioactivity (McNamara).

The harbor at Port Hope was used as a repository for the historic wastes generated by the refinery. An article entitled "Radionuclides in the Great Lakes Basin", published in the journal *Environmental Health Perspectives,* paints a picture of what lays beneath the waters:

> The contamination of water and sediments in the Port Hope harbor due to the release of liquid wastes from the refinery has resulted in the designation of the harbor as an area of concern by the Great Lakes Water Quality Board. Concentrations of uranium and gross alpha-beta radioactivity in harbor waters are often above maximum accept-

> able values defined by the Great Lakes Water Quality Agreement. About 90,000 m^3 of sediment are contaminated with uranium and thorium decay series radionuclides, as well as other heavy metals. Typical contaminant concentrations in the harbor sediments are about 22 MBq/m^3 of 226Ra and 310 µg/g of uranium (Ahier and Tracy).

The widespread contamination throughout Port Hope erupted into a public scandal in 1975. Inside the cafeteria of St. Mary's Elementary School, radon was detected at levels 21 times greater than the regulatory limits then current in Ontario (McNamara). This discovery led to the immediate evacuation of the school, which remained closed for the following two years while remediation work was performed. As the news about St. Mary's spread throughout the town, public panic was ignited. An atmosphere of fear blanketed the town as citizens pondered their possible exposures over the years and the potential ramifications to their health and that of their children. Calls rang out for widespread environmental testing. Hundreds of homes and public buildings, including all the local schools, were monitored.

What percolates beneath Port Hope came to the surface when testing was conducted at Dr. Powers Elementary School. Originally built in 1925, a gymnasium and kindergarten area were added in 1950. Contaminated fill was used during construction, and after the foundation for the additions were completed, the hole was backfilled with contaminated soil. On December 19, 1975, radon testing commenced. Follow-up testing was performed on December 23 and five days throughout January (McNamara). On each day, radon readings were above the allowable level of 3 picocuries per liter of air, the standard then in effect in Ontario. As observed by McNamara: "This allowable level was set to protect workers in a workplace setting. It did not take into account radon's increased risk to children because of their undeveloped immune systems." In July and August 1978, the AECB resumed radon testing at the school. McNamara describes these test results:

> If you look at the sub-slab results in the table above, you will see that radon levels were 14.3 pCi/L or 3.5 times higher than the allowable level [by then 4.0 pCi/L] when the hole through the slab was opened and tested on July 25. The test result the next day was 198 pCi/L or 49.5 times the allowable level.
>
> The first test done on August 8, at 10:30 registered 276 pCi/L or 69 times the allowable level. The second test on August 8, was at 13:30 after the heating system was turned on. The radon level was 506 pCi/L or 126 times the allowable level. Of further concern is that the

> radon levels were still rising when testing was stopped. They plugged the hole in the slab and never spoke of this lethal level of radioactivity under our children again.

The results of these tests were kept from the school board and the parents of children attending Dr. Powers Elementary School. No remediation work was performed. No further monitoring took place. Test results were hidden from the public until 2004.

Residents of Port Hope suspected elevated rates of cancer were occurring in their community. Comprehensive studies were promised by the Canadian government in 1979, but these have yet to be carried out. Health Canada did conduct two studies, published by the Canadian Nuclear Safety Commission in 2000 and 2002, entitled *Cancer Incidence in Port Hope, 1971-1996* and *Cancer and General Mortality in Port Hope, 1956-1997*. These studies gave Port Hope a clean bill of health. In unison, the Canadian government, the Canadian Nuclear Safety Commission and Cameco proclaimed that the studies yielded no significant statistics worthy of concern and that further health studies of Port Hope were unnecessary.

In response, the Port Hope Community Health Concerns Committee arranged to have the two Health Canada studies reviewed by Dr. Eric Mintz. His reassessment of the two previous studies were published in 2000 under the title "Cancer Morbidity Study Critique" and in 2004 in a paper entitled "A Critique of the Mortality Study for Port Hope 2002." The picture he painted of health in Port Hope was greatly at odds with that portrayed by Health Canada. According to Mintz, selected periods and cohorts in Port Hope demonstrated elevations in overall death rate, childhood cancer death rate, circulatory disease, leukemia, non-Hodgkins lymphoma, cancers of the lung, brain, nasal/sinus, esophageal, lip, bone, and colon/rectum (PHCHCC, 2007). Mintz summarized his conclusions as follows:

> The patterns of several cancer rates show cause for concern in that the patterns are consistent with environmental contamination and certainly the raised leukemia rates, which were even higher before remediation, are not reassuring. Along with the brain cancer, colon cancer and some of the rare cancer results, the available evidence points to there being problems in Port Hope (Mintz 2004).

Rosalie Bertell had this to say about the conclusions drawn by Health Canada in its studies:

> Health Canada's claim of "no problem" to area residents from 70 years of exposure is fraudulent and not supported by the data presented in the report.

> I think that the basic statement that the cancer rate in Port Hope is no higher than the rest of the province is misleading. When you look at Ontario with much of the population living in high-industry, high-pollution areas (Windsor, Sarnia, Greater Toronto), you would expect Port Hope (a rural environment) to be a healthier place to live. The cancer rate in Port Hope should be 20% below the provincial average, not equal to it, as stated in the report (McNamara).

With Health Canada unwilling to fund and carry out anything other than questionable retrospective studies, members of the Port Hope Community Health Concerns Committee (PHCHCC) set about initiating a small indicator study of their own. In 2004, they approached the Uranium Medical Research Center in Toronto, asking for help in designing and implementing a relevant study. The UMRC, donating its services, drew upon its medical and scientific expertise to conduct a quantitative analysis of the internal contamination of uranium isotopes among a small study group of Port Hope residents. After the federal government, the municipality and Cameco declined to support the project or contribute funding, a local fundraising drive was undertaken. Eleven thousand dollars were donated which was used to pay for the expensive laboratory procedures. The PHCHCC then proceeded to interview applicants for the study who volunteered either on the basis of their exposure history or their health issues. All nine participants in the study group had a history of unexplained illnesses, chronic or congenital medical problems, or a history of family health problems. Four of the nine had worked for Cameco or Zircatec Precision Industries in Port Hope. The remaining five were residents of the town who lived in the plume pathway of the nuclear facilities.

The results of the study were presented in October 2007 at the Annual Congress of the European Association of Nuclear Medicine in Copenhagen. In "The Quantitative Analysis of Uranium Isotopes in the Population of Port Hope, Ontario, Canada," Durakovic and colleagues reported that 24-hour urine samples were obtained from nine subjects residing in Port Hope "presenting with multi-system, nonspecific symptoms of immune system alterations, musculoskeletal, central nervous system, and neoplastic disease." In addition, samples were collected from two control subjects who resided in other parts of Ontario. The samples were then sent to Frankfurt, Germany, for analysis by plasma ionization mass spectrometry at a specialized radiochemistry laboratory at the Institute for Mineralogy at J.W. Goethe University. The authors summarized the lab results as follows:

> Our results show 4 of 9 samples containing uranium of nonnatural origin. Subject 3 was highly positive for depleted uranium with a 238U/235U ratio of 147.11 ± 1.42 and a relatively normal abundance of total uranium. This sample contained a concentration of

> 236U with a 236U/238U ratio of 4.38 x 10^{-6} ± 4.3 x10^{-7} indicating its reactor origin. Three other subjects (2, 4, and 6) contained detectable amounts of 236U. Subject 6 had a paradoxically high 236U/238U ratio of 5.53 x 10^{-5} ± 3.9 x 10^{-6}. Subject 2 also had a higher than normal concentration of total uranium at 24.8 ng/L. The 236U in these samples indicates its origin as contamination with nonnatural uranium. The remaining five subjects were negative for both depleted uranium and uranium-236. Control subjects had no detectable 236U and a normal concentration of total uranium in their urine. Control subject 2 had a natural 238U/235U ratio. However control subject 1 had 238U/235U ratio that was slightly depleted. It was learned after testing that this person had visited Port Hope at some time prior to giving their sample.

At a press conference held in Toronto by UMRC and PHCHCC, further information was presented regarding the test subjects (PHCHCC, November 2007). Three of those subjects who had worked in the nuclear industry showed evidence of chronic, long-term uranium contamination, excreting unnatural (man-made) uranium isotopes and depleted uranium at 23, 17 and 11 years respectively after the completion of occupational exposure. The worker with exposure 23 years prior to the study had worked for Eldorado Nuclear in the 1980s, extruding depleted uranium metal rods destined for US weapons. His urine provided evidence of ongoing elimination of DU. In addition, the measure of total uranium in subject number 2 was eight times the average of total uranium in the study's two control subjects. The finding that proved particularly controversial was the presence of the isotope uranium-236 in some of the samples. Uranium-236 is not found in nature. It is produced in a nuclear reactor when atoms of uranium-235 capture an additional neutron. Thus, its presence in Port Hope is not the result of the refining of natural uranium. The only explanation for the presence of this isotope is that Cameco was receiving and recycling reprocessed reactor fuel, turning it into products for the nuclear industry.

Another significant point of the Port Hope study which received no elaboration in the UMRC paper at the time of its publication was the presence of uranium-234 in the urine samples. The ratio of uranium-234/uranium-238 was elevated above the levels measured in the two control subjects in all nine of the study subjects, including in a child under the age of 14. (The measure of total uranium in this child was three times greater than the average of that of the two control subjects). Uranium-234 does occur in nature. But its presence in the test subjects was elevated above naturally occurring levels. Its presence is a mystery. What could its origin possibly be? According to Tedd Weyman of UMRC, elevated levels of uranium-234 have in the past been attributed to elevations in drinking water due to the unique chemistry of this isotope in natural uranium by which it

can be leached out into wells and other water courses. But this explanation was discarded for Port Hope due to the fact that the subjects derived their drinking water from different sources, some from private wells and some from the municipal water system supplied by Lake Ontario. The other known source of elevated levels of uranium-234 is in enriched uranium, since during the enrichment process this isotope initially follows uranium-235 through the cascades. But what is enriched uranium doing in Canada? Candu reactors are fueled by natural uranium. There are two explanations. First, Zircatec Precision Industries at one time advertised that they assembled fuel bundles for nuclear reactors in the United States. These reactors are fueled by slightly enriched uranium. Second, at a Canadian Nuclear Safety Commission public hearing in Oshawa on January 9, 2008, Cameco admitted that it has received at its facility and processed recycled/down-blended uranium,[5] and further, that it has processed and blended dirty US uranium containing uranium-236. This situation clearly demonstrates the power of independent science to bring secretive industry to account. Public disclosure of what Cameco has been up to in downtown Port Hope came to light only after the measurement of uranium isotopes in biological samples of the town's residents.

The significance of UMRC's discoveries were summarized in a letter from Ted Weyman to Tony Clement, Minister of Health:

> * One worker's urine contains Depleted Uranium (DU), the "tails" of the uranium enrichment process. Canada does not enrich uranium although the record shows the Defense Research Establishment (DRE-DND), the Royal Military College (DND) and Cameco have imported DU for US/NATO weapons R&D and to produce components for US anti-amour DU munitions, respectively.
>
> * All nine subject's (i.e. former workers, both male and female adults, and one child) urine contain elevated abundances of the uranium isotope, 234U. Elevated 234U is a forensic signature of "downblended" or recycled, enriched uranium. Dirty uranium is not identified in Natural Resources Canada's (NRCan) public documents associated with radioactive waste in Port Hope nor is it mentioned in CNSC's regulatory documents. Neither are there references to it in the NRCan/AECL Port Hope Environmental Assessments (EA) or the Municipality's Peer Review reports. This constitutes serious omissions

[5] As mentioned previously, it is known that enriched uranium has been blended with depleted uranium to create a product with ratios of uranium-235 to uranium-238 resembling that of natural uranium. However, this process invariably results in an unnatural elevation of the isotope uranium-234. This is its signature by which it can be differentiated from natural uranium.

> in the licensing reviews, the dose modeling, the EA's and the Peer Reviews.
>
> * The findings demonstrate that emissions from the nuclear plants contain isotopes that are different in chemistry, form, radioactivity and biological effects than the species of uranium licensed for import and processing by Cameco and Zircatec.
>
> * The contaminants found are substantially different from the species of uranium Health Canada and CNSC base the calculations of the allowable radiation doses in Port Hope. For example, the elevated uranium isotope 234U is 18,500 times more radioactive than the primary isotope processed in Port Hope, 238U (Weyman 2008).

Health Canada acted quickly to pacify the public concerns ignited by the UMRC study. On November 19, 2007, Dr. Jack Cornett, Director of Radiation Protection, Health Canada, attended a town council meeting in Port Hope. He announced that the study's results were not significant, that people living in Port Hope had nothing to worry about, and that the contamination reported in the test subjects was typical of all Canadians. Further, he attested that if all residents in Port Hope were tested or if all Canadians were tested, they would have the same radioactive materials in their bodies (PHCHCC, December 2007). A rebuttal to Dr. Cornett's statements appeared in an article two weeks later:

> Tedd Weyman, Deputy Director, Uranium Medical Research Center said Health Canada's staff have misunderstood the basic physics in the findings made public two weeks ago. "Health Canada attempts to attribute the contamination to current daily intake of naturally occurring uranium in water. The lab data shows a very different picture," says Weyman. "They show chronic internal contamination from inhaling airborne radioactive toxins. What we found is not naturally occurring; the contaminants are manmade, commercial nuclear materials, referred to as "dirty uranium."
>
> UMRC expressed surprise at Cornett's statement that the findings are "typical" for Canadians. Weyman agrees the contamination profile is most likely typical for Port Hope. However, says Weyman "there are no scientific literature or government reports agreeing with Dr. Cornett's statement that it is typical of Canadians' bodies to contain spent nuclear reactor fuel, depleted uranium or enriched 234 uranium."

> Weyman noted that the study's two control samples, taken from persons who don't live or work in Port Hope, are not contaminated. "The controls show none of the contaminants Dr. Cornett says are 'typical' in Canada."
>
> Health Canada told the Port Hope Council the doses of radiation are too low to be important. Weyman says Health Canada is making up its facts. Health Canada, just like the patients and UMRC, has no idea how much radioactive contaminant has been incorporated into the patients' bodies. It is impossible to calculate the radiation dose without historical reconstruction of the exposure history of each subject (PHCHCC, December 2007).

Following the press conference by UMRC and PHCHCC, newspapers across Canada carried the story. Many in Port Hope resented the national spotlight being focused on their community. A developer who had invested $25-million to build 1,200 homes in Port Hope's west end had this to say about PHCHCC and FARE, Families Against Radiation Exposure: "I just find it pathetic [that the two groups would] put out misinformation to damage their own community" (Lloyd). An editorial in *Northumberland Today* on December 4, 2007 observed that the large turnout for the annual Santa Claus parade provided little evidence that it was the same community "that has been smeared, besmirched and repeatedly bashed by some of its own residents over the past few weeks." Further into the editorial were these choice words: "Sad to say, it seems anyone can come forward with any half-baked evidence and if the story sounds sexy enough, it will get coverage." An article entitled "Backlash: The Risk of Speaking Out," published in *Waterkeeper.ca Weekly* had this to say:

> The backlash came fast and furious after grassroots groups released details of uranium contamination in human test subjects from Port Hope, Ontario in November. Private citizens, pundits and government officials condemned their neighbors for voicing concerns about uranium pollution.
>
> Scientists and community organizers were labeled, "small, but loud, self-interest groups." They were accused of using "terrorist tactics," and being "willing to do whatever they have to to get attention, regardless of the cost to the community." Even the local MP had harsh words, criticizing the groups for bringing "needless, negative attention" to the town.
>
> In the immediate aftermath of the November press conference, a

> reported 3,000 residents and Port Hope merchants took to the streets to "save Port Hope." Business owners and government officials dominated newspapers and television news broadcasts.
>
> Whether calculated or merely coincidental, their collective response followed a pattern that Waterkeeper has seen in dozens of communities facing environmental concerns.
>
> First, the individuals and organizations who spoke out are ostracized. They are labeled troublemakers, do-gooders, or wackos — anything that might separate them from "ordinary folk." This makes it harder for you and I to identify with their message or to share their concern. (See, for example, repetition of marginalizing terms in the Port Hope coverage such as "self-interest," "terrorist," "minority," etc.)
>
> Second, access to a fair forum is limited. The public (regardless of point of view) is offered no independent decision-makers, scientific experts, counsel, testimony under oath, ability to cross-examine other speakers, or opportunity to appeal.
>
> The whole point of a fair forum — be it a panel review, environmental assessment, a hearing at the Environmental Review Tribunal, or a traditional court of law — is to get at the truth. To lay all the facts on the table. To test the assertions of every side. To bring a community together.
>
> In a town like Port Hope, where neighbor is pitted against neighbor and the most basic information is not available, a full investigation is the only legitimate option. Every community has a right to know what property is polluted and what the contaminants are. Every community has a right to know what is being done to clean up those contaminated lands. Port Hope is no different.

Returning to the study published by UMRC, the researchers concluded their paper with this observation:

> The inadvertent exposure and toxicology of uranium isotopes in both military personnel and civilians employed in the nuclear industry or living in the vicinity of uranium processing plants has been well documented. Both parenteral and oral administration of uranium isotopes has been studied in animal studies and humans. Of particular interest are inhalation pathway toxicity studies which confirmed sig-

nificant renal and pulmonary damage with 11 uranium compounds including oxides, fluorides, tetrachlorides, and nitrates in six different animal species as well as humans. Most recent studies of the Gulf War veterans have estimated a significant carcinogenic risk of inhaled depleted uranium. Uranium containing dust has been identified as the most important source of radiation exposure in uranium mining and processing. Toxicity of uranium in the ground waters (Saskatchewan, Canada), higher risk of lung cancer in uranium miners (New Mexico, Arizona), overall cancer risk in workers involved in the uranium processing industry (Ohio, Colorado), and numerous published studies from around the world all point to the realistic probability of adverse health effects of uranium isotopes in the human population living in the vicinity of nuclear processing plants.

The history of uranium contamination in Port Hope is well documented. Our results provide the first objective analytical study of long-term contamination and possible association with adverse health effects in the current population of Port Hope. These preliminary results warrant additional multidisciplinary studies.

12

Unexplained Illness and the Radioactive Battlefield

> Army officials believe that DU protective methods can be ignored during battle and other life-threatening situations because DU-related health risks are greatly outweighed by the risks of combat.
>
> (US General Accounting Office, 1993)

On August 2, 1990, Iraq invaded Kuwait. In response, a coalition of 39 countries, led by the United States, raised an army to repel the occupation. The air campaign of Operation Desert Storm began on January 17, 1991. The ground campaign got under way on February 24. One hundred hours later, the war was over. Kuwait was liberated. A ceasefire was declared. What remained of the routed Iraqi army limped back toward Baghdad, corridors of destroyed and abandoned matériel marking its retreat.

The coalition force totaled more than 883,000 soldiers. Of these, 697,000 were United States military personnel, 53,000 were servicemen from the United Kingdom and 4,500 were soldiers from Canada. For such a large offensive, the casualty count was surprisingly low. Prewar mortality projections ranged from below 6,000 to as many as 40,000. However, the actual number of coalition combat deaths was around 378. The number of wounded was less than 1,000. Among the American contingent, 148 service personnel died in combat. Of these, 35 were victims of friendly fire (Helmkemp). An additional 145 soldiers died from disease or accident (Presidential Advisory Committee). The number of wounded totaled 467.

For far too many veterans, the rapid cessation of fighting did not mean that the war was behind them. At camps throughout the combat theater, GI's with no apparent wounds of battle began reporting for sick call in increasing numbers. Just months later, back in the US, fort hospitals were inundated with returning soldiers. They complained of a baffling array of symptoms that defied known disease categories. In years following, discharged veterans flooded VA hospitals seeking medical care for various kinds of incapacitation. When physical exams and standard diagnostic tests failed to define the maladies veterans reported, military physicians informed their patients that they were suffering from post-traumatic stress disorder (PTSD), and that their problems were all in their heads. Muscle relaxants and sleeping pills were prescribed and mental illness assessments were ordered. But the ongoing influx of sick veterans testified unambiguously that this diagnosis was inadequate and fallacious. Some unexplained noxious influence had ravaged America's fighting force, leaving a large proportion of fit men and women, in the prime of their lives, sick and debilitated. According to the National Gulf War Resource Center, more than 263,000 veterans sought medical care through the Department of Veterans Affairs. As of May 2007, the Gulf War Veterans Information Service recorded that 407,911 deployed veterans had filed claims with the VA for service-related medical disabilities and that 313,214 of these claims had been accepted, permitting compensation and pensions to be granted (DVA 2007).

The symptoms of the mysterious malady that destroyed the lives of this cohort cover a wide spectrum. They include general malaise, irritability, psychomotor agitation, incapacitating fatigue, persistent headaches, visual problems, sleep disturbances, sinus troubles, joint and muscle pains, coughing, chest pains, bronchitis, shortness of breath, asthma, hypertension, abdominal pains, chronic indigestion, chronic diarrhea, skin rashes, hair loss, night sweats, impotence and burning semen. Reported neurological symptoms include cognitive dysfunction, speech difficulties, memory loss, a difficulty concentrating, loss of muscle control, dizziness, confusion, depression and psychological distress.

At a loss to diagnose what has become popularly known as Gulf War Syndrome, the VA refers to the plight of veterans as an "unexplained illness." According to the VA's Uniform Case Assessment Protocol: "An 'unexplained illness' is defined as one or more symptoms, generally without objective clinical findings, which do not conform to a characteristic clinical presentation allowing for a diagnosis, but which appear to be causing a decline in the veteran's functional status or quality of life (DVA)." Summarizing numerous descriptions by a number of authors, the unexplained illness from the Gulf can be further characterized as a complex, progressive, chronic, incapacitating, multi-symptom, multi-organ system disorder which is not consistently associated with any objective physical signs or laboratory abnormalities.

Amidst all the uncertainty, one fact is well established. Deployment in Kuwait and Iraq was an etiological factor in the development of this “unexplained illness.” Deployed veterans routinely report more symptoms — and more severe symptoms — than their non-deployed counterparts. As stated by the Research Advisory Committee on Gulf War Veterans’ Illnesses: “Population-based studies consistently indicate that between 26 and 32 percent of Gulf veterans experience a multi-symptom pattern of illness, over and above rates experienced by veterans who did not serve in the Gulf War.” Some of the studies which support this conclusion are (1) USA: Iowa Persian Gulf Study Group, Fukuda *et al.*, Doebbeling *et al.* (2) UK: Unwin *et al.*, Cherry *et al.*, Reid *et al.* (3) Denmark: Ishoy *et al.* It is important to note that for those veterans who report symptoms, their cases do not cluster by time, duration or location of deployment; by military occupational specialty; or by direct participation in combat (DVA). Further, a study of Kansas veterans revealed that those who fought and served in Iraq or Kuwait were more likely to report symptoms compared to veterans who served primarily on board ships during the war (DVA).

The Gulf War battlefield was nightmarishly toxic. In addition to the hazards of combat, warriors were exposed to a number of pernicious influences which, alone or in combination, destroyed their health. These enemies, more intangible and insidious than the Iraqi army, included infectious agents, chemical warfare agents, vaccines and environmental pollutants. As the magnitude of the health catastrophe created by the war came to light, these toxins became the focus of research into the etiology of the unexplained affliction. The possible causative factors of Gulf War Illness include the following:

Pyridostigmine Bromide — Classified by the FDA as an “investigational new drug,” PB was administered as a pretreatment to soldiers to moderate the effects of the chemical warfare nerve agent soman. PB reversibly binds to acetylcholinesterase (AChE), thereby offering protection from subsequent exposure to nerve agents that irreversibly bind to AChE. According to the Department of Defense, about 250,000 troops were exposed to either a partial or full treatment regime of the drug. PB is normally prescribed for *myasthenia gravis*. It is known to have serious side effects and interactions when taken in combination with other drugs, vaccines, chemical exposures, heat or physical exercise. Animal studies have indicated that exposure to pesticides and insecticides can accentuate PB’s toxicity.

Anthrax Vaccine — Prior to being sent to the Gulf, military personnel were inoculated for protection against cholera, diphtheria, meningitis, plague, pertussis, rabies, tetanus and typhoid. After arriving in the theater of operations, an FDA-approved non-live vaccine was selectively administered to a subpopulation of the fighting force for protection against weaponized anthrax (*Bacillus anthracis*). As a biological warfare agent, anthrax is

nasty. Once inhaled, spores are transported via the lymphatic system to the mediastinal lymph nodes. There they germinate, usually within a few days, but germination can be delayed for up to 60 days. Following germination, the rapidly replicating bacteria release toxins that cause hemorrhage, edema and necrosis. Once symptoms have begun, pulmonary anthrax infection is almost always fatal. To prevent this illness, vaccinations were administered to 41 percent of US combat soldiers and between 57 and 75 percent of UK combat soldiers. According to the VA, there is little published, peer reviewed literature on the possible long-term health consequences of exposure to the anthrax vaccine (DVA). The Research Advisory Committee on Gulf War Veterans' Illnesses had this to say of the vaccine:

> A number of potential problems with the anthrax vaccine have been suggested, including problems with quality control during the manufacturing process, changes in the manufacturing process that may have resulted in increased levels of active antigen, and the use of unapproved adjuvants to bolster the immunological reactivity of the vaccines. Reports have indicated that the anthrax vaccine administered during the Gulf War, commonly referred to as AVA (anthrax vaccine adsorbed) is associated with a relatively high rate of acute adverse reactions, and have pointed out that there is insufficient evidence to determine whether the AVA vaccine formulation may be associated with long-term health sequelae.

Botulinum Toxoid Vaccine — Botulinum toxins are among the most poisonous substances found in nature. They are isolated by fermentation from *Clostridium botulinum*, a commonly occurring bacterium. Different strains of the bacterium produce seven distinct strains of toxins. Inside the human body, these neurotoxic proteins inhibit the release of acetylcholine, thereby interfering with the transmission of nerve impulses. In response to fears that Iraq had biological weapons containing botulinum toxins, 8,000 soldiers were inoculated with botulinum toxoid. This unproven vaccine is classified by the FDA as an "investigational new drug." According to the Department of Veterans Affairs:

> Early studies of the initial toxoids (in the 1940's) found a significant number of local and systemic reactions. Later research that focused on the efficacy of the vaccine noted moderate local or systemic reactions. Studies of the vaccine have not used active surveillance to systematically evaluate long-term health consequences (DVA).

Leishmaniasis — Systemic leishmanial infection is caused by a one-celled parasite (*Leishmania tropica*) which is transmitted by the bite of many species of sandfly which are

indigenous to the Gulf region. According to Bertell:

> Non-indigenous people who enter an infected area are known to be more seriously affected by this parasite than the inhabitants. If left undiagnosed, and therefore untreated, it can be fatal. Diagnosis requires bone and spleen biopsy, and the disease can have a three-year incubation period without causing symptoms. It can be transmitted by blood transfusion, and transmitted by a woman to her unborn child. Leishmaniasis was reported as widespread in Iraq and Saudi Arabia. This disease is thought to be responsible for the Pentagon ban, November 1991, against blood donations from Gulf War veterans. This ban was lifted, for unknown reasons, on January 11, 1993 (Bertell, Gulf War Syndrome).

According to the Department of Veterans Affairs, Leishmaniasis was diagnosed in just 12 US veterans. Further, "*L. tropica* infection is not thought to be a widespread cause of chronic symptoms among veterans, because there have been no further cases in eight years and because all but one infected veteran had objective signs of disease that would be apparent on physical examination, principally due to an elevated temperature and an enlarged liver or spleen" (DVA).

Infections — Some researchers have suggested that chronic bacterial infections are responsible for the illnesses suffered by Gulf War veterans. Among a small number of suspected causative agents, Mycoplasmas have received a lot of attention. These are the smallest free-living organisms known to infect humans. Mycoplasmas are microorganisms smaller than bacteria but larger than viruses. They lack the rigid cell walls common to most bacteria, bound instead by a unit membrane. Mycoplasma infections have repeatedly been detected in studies of Gulf War veterans. According to Nijs and Nicolson: "A high prevalence of *Mycoplasma spp*. (around 50%) has been consistently reported in various samples of GWI patients (Nicolson *et al*. 1998, 2000; Vojdani and Franco). In some instances, similar illnesses to that of Gulf War disease has developed in family members and household pets of returning veterans (DVA), and they too have tested positive for Mycoplasma infection (Nijs and Nicholson). Further, some veterans have reported improvement in their chronic symptoms after tetracycline and doxycycline antibiotic therapy (DVA).

Chemical and Biological Warfare Agents — According to both the US Department of Defense and the British Ministry of Defense, neither chemical nor biological weapons were intentionally used by Iraqi forces against coalition forces during the Gulf War (DVA). Nevertheless, exposure to chemical and biological warfare agents may have taken place. British forces had in their possession automatic alarms that were designed to

be triggered in the presence of a number of chemicals, and it is well documented that these were set off thousands of times throughout the war. After the ceasefire, in March 1991, US troops from the 37th and 307th Engineering Battalion destroyed Iraqi munitions in many areas of southern Iraq. Among their targets was the ammunition depot at Khamisiyah. This large storage complex contained more than 100 bunkers, all of which were destroyed. Unbeknownst to the demolition teams, 122 mm rockets stacked at two sites within the complex contained the nerve agents sarin and cyclosarin. Only in October did inspectors from the United Nations Special Commission confirm that these nerve agents were released into the environment from Khamisiyah.

Sarin was synthesized in Germany in 1937 in the course of research on insecticides. It is a member of a class of chemicals known as organophosphorus esters (or organophosphates). As described by Fulco *et al.* in *Gulf War and Health*:

> Since AChE is responsible for the breakdown of the neurotransmitter acetylcholine (ACh), the inactivation of this enzyme results in a dramatic elevation of ACh levels at cholinergic synapses. The term "cholinergic synapses" refers to sites throughout the body where acetylcholine exerts its actions at the synapse, or junction, between nerve cells or between nerve cells and skeletal muscles. Widespread overstimulation of muscles and nerves induced by excessive levels of acetylcholine is primarily responsible for the acute cholinergic syndrome triggered by exposure to sarin and other organophosphate (OP) nerve agents.

According to the Department of Veterans Affairs: " Acute cholinergic poisoning symptoms usually develop within hours of exposure and include miosis, headache, nausea, dizziness, anxiety and restlessness. Life-threatening symptoms may include muscle fasciculation, weakness, tremor, uncoordination, vomiting, abdominal cramps, diarrhea, sweating, salivation and excessive tearing; death can occur by respiratory paralysis."

In 1997, the CIA modeled the possible atmospheric transport of the nerve agents away from Khamisiyah. Based on this work, the Department of Defense notified nearly 100,000 Gulf war veterans who may have been in the path of the plume that they might have been exposed to the nerve agents, though at levels too low to cause any acute cholinergic poison signs and symptoms.

Pesticides and Insecticides — To protect military personnel from endemic pests, the Department of Defense shipped 21 different pesticides and insect repellents to the Gulf. According to the Presidential Advisory Committee on Gulf War Veterans' Health,

these included carbaryl (Sevin®), chlorpyrifos (Dursban®), DEET (for example OFF® and Cutters®), diazanon, dichlorvos (Vapona®), lindane, malathion, methomyl (Lannate®), permethrin, propoxur (Baygon®), pyrethroids and rodenticide baits (DVA). Many of these are toxic nerve agents. Levels of exposure to troops are undocumented.

Smoke from Oil-Well Fires — Before withdrawing from Kuwait, Iraqi soldiers created an environmental catastrophe by setting fire to 750 oil wells. Among the pollutants liberated into the atmosphere were ozone, nitrogen dioxide, sulfur dioxide, carbon monoxide, hydrogen sulfide, volatile organic compounds (benzene, toluene, etc.), polycyclic aromatic hydrocarbons (anthracene, pyrene, etc.), heavy metals (cadmium, chromium, lead, nickel, mercury, canadium) acidic gases/aerosols (hydrochloric acid, nitric acid, sulfuric acid), and ultrafine particulate matter (Research Advisory Committee). According to the National Toxics Campaign in Boston, there were five different hydrocarbon products in the smoke which could have induced serious health effects. There were 1,4-dichlorobenzene, 1,2-dichlorobenzene, diethyl phthalate, dimethyl phthalate and naphthalene (Bertell, *Gulf War Syndrome*). In addition to these, troops were exposed to the products of combustion from vehicle and aircraft exhaust, tent heaters, cook stoves and the open burning of trash and wastes.

Pervasive Psychological and Physiological Stress — According to the Presidential Advisory Committee on Gulf War Veterans' Illness: "Stress is known to affect the brain, immune system, cardiovascular system, and various hormonal responses. Stress manifests in diverse ways, and is likely to be an important contributing factor to the broad range of physiological and psychological illnesses currently being reported by Gulf War veterans."

Depleted Uranium — Contamination of the Gulf War battlefield with DU created numerous opportunities for military personnel to receive exposure. All Iraqi vehicles and bunkers destroyed by DU munitions became dusted with ultrafine, uranium-bearing particles. Surveys have indicated that 75 percent of soldiers on the ground in the Kuwaiti Theater of Operations came into contact with destroyed tanks and vehicles (Fahey 1998). Not properly informed of the hazards of the radioactive battlefield, soldiers went sightseeing amid the rubble and hunted for souvenirs, and were thereby exposed unnecessarily. They would not have had to be in direct contact with destroyed Iraqi equipment to have become internally contaminated. The smoke plumes created by each successful hit with DU munitions vented DU into the atmosphere. Soldiers downwind of the destruction likely inhaled radioactive particles. DU settling in the sand in the immediate vicinity of each impact site or carried some distance downwind in the smoke was, and still is, continually resuspended by desert winds and scattered about the countryside.

It is highly likely that specialized groups within the military received internal exposure to DU. In addition to the 50 soldiers known to have been wounded in friendly fire incidents, an additional 72 uninjured soldiers were riding in the vehicles destroyed by DU munitions (Fahey 1998). Other groups include vehicle recovery and maintenance personnel who worked on US equipment hit by friendly fire, members of the Depleted Uranium Assessment Team, and medical personnel who treated those wounded by friendly fire.

In July 1991, a fire broke out at a motor pool and ammunition storage area in Doha, Kuwait. The blaze consumed 15 million dollars in ammunition, including 660 120mm tank rounds made up of 7,062 pounds of DU (Fahey 1998). Four M1A1 tanks, armored with DU, were also engulfed in flames and burned. Inhaling smoke from this inferno were 3,700 soldiers of the 11th Armored Cavalry Regiment; 200 British soldiers with St. George's Lines; and an unknown number of personnel from the 21st Evacuation Hospital (Forward), the 912th MASH and the 519th MASH (Fahey 1998).

Between 1994 and 1999, the federal government funded 145 research studies into the illnesses of Gulf War veterans at a cost of over $133 million (USDVA). These studies were carried out primarily through the Department of Defense, the Department of Veterans Affairs and the Department of Health and Human Services. Despite this exhaustive undertaking, the origins of the ailments suffered by veterans remains a mystery. Confounding the mystery is the conclusion reached by a number of committees that it is unlikely that any of the toxic substances mentioned above are associated with the health problems reported by veterans (Presidential Advisory Committee; Institute of Medicine 2006).

The conclusions reached by these government-sponsored initiatives distinguish themselves by a disturbing omission, an omission that clouds trust in their conclusions. Exposure to depleted uranium has not been adequately investigated to justify the verdict that it plays no part in making veterans ill. Most studies reject DU out of hand as a causative factor. This dismissal is based on theoretical calculations of the dose delivered to tissue from internalized DU and the insignificance of this dose within the ICRP model of radiation effects. It is also based on stale research on the uranium exposure of workers in the nuclear industry. This research may not be relevant to the type of exposure incurred on the battlefield. (A fuller discussion of this topic is presented in a later chapter on DU's health effects.) Large-scale studies have not been performed on veterans suffering symptoms of the "mystery" disease of the Gulf to detect how many of them are contaminated with DU. Until such studies are performed, rejection of DU as a etiological factor is premature and unwarranted.

Science is the crown of humanity's intellectual development. It is the means by which we uncover truth about phenomena in the physical world. Science is the sword we use to banish ignorance and defeat falsehood. Given our propensity to trust the results of honest experimentation, the inquiring mind has to ask itself this question: Why is important research on human exposure to DU systematically ignored by government-sponsored studies delving into the causes of the "unexplained" illness suffered by veterans? In a number of small human studies, objective, peer reviewed science has confirmed that depleted uranium is present in the bodies of people suffering the symptoms of Gulf War disease. This data cannot simply be swept under the carpet. No matter how many high and mighty committees conclude that DU did not adversely affect veterans' health, as long as they ignore the documented scientific evidence, they expose themselves to charges of unprofessionalism, lack of objectivity and fraud. The common disregard of the objective evidence is telling. It is a self-imposed indictment by those investigating the health of veterans that their quest for truth is not genuine and their conclusions are not to be trusted.

A compelling thread of evidence suggests that DU is associated with the undiagnosed illness of Gulf War veterans. This thread stretches back to the immediate aftermath of the Gulf War. King Khalid Military City in Saudi Arabia was the site of a vehicle maintenance collection point, the terminus for the broken and destroyed military vehicles of Operation Desert Storm. The 144th Service and Supply Company of the New Jersey National Guard operated the facility, preparing recovered equipment for shipment back to the United States. Among the vehicles brought in for processing were 29 Bradley Fighting Vehicles and Abrams tanks which had been hit by friendly fire. Unbeknownst to the 144th, this equipment was contaminated with depleted uranium. For several weeks, the 27-man crew worked on the vehicles, oblivious of the need for proper respiratory protection and other radiation safety precautions. Eventually, the Depleted Uranium Assessment Team appeared on the scene, informing the crew of the radiation hazard they had been exposed to. The two units then worked together for several more weeks readying the equipment for shipment back to the US.[1]

In January 1992, the General Accounting Office began an investigation into the use of depleted uranium in the Gulf. Two months later, in response to this initiative, the Veterans Administration began testing selected members of the 144th for exposure to DU. The medical testing of the 144th precipitated a momentous skirmish within the VA and Department of Defense. To appreciate what transpired, the reader need to understand the pivotal significance of the type of radiation exposure received by members of the 144th.

[1] A fuller account of the experience of the 144th Service and Supply Company can be found in *Depleted Uranium Case Narrative* by Dan Fahey.

After the Gulf War, the United States began to be criticized for using depleted uranium as a weapon of war. In defense of its actions, the government and the military adopted the position that the only people at risk from exposure to DU were those who received shrapnel injuries. But the Depleted Uranium Assessment Team had witnessed the members of the 144th crawling around highly contaminated equipment for weeks. If these men were found to be contaminated with DU, a Pandora's box would be opened, forcing the government to acknowledge that battlefield DU presented an inhalation hazard to a far larger population than those directly injured by shrapnel.

Given the stakes involved, members of the 144th were examined and tested repeatedly. Their story is summarized in the chart on the following page. The first published information of test results of the 144th appeared in 1993, in the General Accounting Office study entitled *Army Not Adequately Prepared to Deal With Depleted Uranium Contamination*. This work quoted the Army Surgeon General's Office which stated that 12 of 27 veterans of the 144th had been tested, and that "the presence of uranium is within applicable regulatory limits or that uranium was not present at all" (Fahey 1998). Two years later, the US Army Environmental Policy Institute published *Health and Environmental Consequences of Depleted Uranium Use in the US Army*. It stated that "as of May 1994, preliminary results of nine of the 26 personnel, at the time of specimen collection, were not positive for DU." As the chart reveals, with one notable exception, all further reports embraced the conclusion that members of the 144th were not contaminated with depleted uranium. Examination by Dr. Asaf Durakovic, then Chief of Nuclear Medicine at the VA Medical Center in Wilmington, Delaware, produced a totally contradictory assessment. Testifying before Congressman Shay's Subcommittee on Human Resources, Durakovic reported that 14 of 24 veterans showed signs of internalized uranium (Fahey 1998).

Durakovic has reported in numerous interviews that during the assessment of his patients, every effort was made to disrupt his work. The medical records of the 144th held by the Persian Gulf Registry of the Wilmington VA were lost. Of the urine samples sent to the US Army Radiochemistry Lab in Aberdeen, Maryland, some never reached the lab and others were misplaced. His recommendations for further follow-up studies for the members of the 144th were ignored. In 1997, Durakovic lost his job with the VA due to "downsizing" (Fahey 1998). Nevertheless, Durakovic's medical expertise has been vindicated. Members of the 144th have within their service records letters of "Confirmation of Depleted Uranium Exposure" (Fahey 1998). Reports published by the Defense Science Board, the Institute of Medicine (1996) and the Presidential Advisory Committee all quote the Army Surgeon's Office that the number of personnel in the Gulf War exposed to DU was 52: 35 wounded in friendly fire incidents, and 27 from the 144th Service and Supply Company (Fahey 1998).

Conflicting Reports on DU Testing of 144th Service and Supply Company[2]

Source	Number of Vets that Provided Urine Tests	Number of Vets that Provided Whole-Body Counts	Date of Testing	Results
US General Accounting Office January, 1993 GAO/NSIAD-93-90	12	Not Specified	November, 1992	"within applicable regulatory limits or uranium was not present at all."
US Army AEPI Report on DU, June, 1995	9	Not Specified	As of May, 1994	Negative
Dr. Asaf Durakovic June 26, 1997 Shay's Committee	24	24	Not Specified	14 vets showed radioactive decay products of uranium
Bernard Rostker June 26, 1997 Shay's Committee	12	Not Specified	Not Specified	"No indications of radioactivity or renal toxicity."
Dr. Susan Mather March 25, 1998 VA's DU Teleconference	8	12	Not Specified	"No residual DU was detected."
US Army CHPPM Lab Results No Date Given	13	Not Specified	June, 1993	Negative

[2] This chart is reproduced from *Depleted Uranium Case Narrative* by Dan Fahey. There, it is footnoted with the following:
Army Not Adequately Prepared to Deal With Depleted Uranium Contamination; US General Accounting Office; GAO/NSIAD-93-90; January, 1993; p. 23. *Health and Environmental Consequences of Depleted Uranium Use in the US Army*; US Army Environmental Policy Institute; June, 1995; p. 128. Durakovic, Dr. Asaf; Prepared Statement before the Subcommittee on Human Resources, Committee on Government Reform and Oversight, US House of Representatives; June 26, 1997. Rostker, Bernard; Statement before the Subcommittee on Human Resources, Committee on Government Reform and Oversight, US House of Representatives; June 26, 1997. Mather, Dr. Susan; transcript of March 25, 1998 VA/DoD satellite teleconference on DU Program. "Laboratory Results — Urine Uranium Levels in Bioassay Specimens for Individuals of the 144th Service and Supply Battalion, New Jersey National Guard;" US Army Center for Health Promotion and Preventive Medicine; no date given.

After leaving the VA, Durakovic established the Uranium Medical Research Center in Toronto, Ontario. While there, he and his colleagues developed the first accurate method for detecting depleted uranium in the urine of contaminated individuals by determining the ratios of uranium isotopes after analysis with a thermal ionization mass spectrometer using a secondary multiplier (SEM) detector and ion counting system (Horan and Durakovic, Durakovic *et al*. 2002). In *The Quantitative Analysis of Depleted Uranium Isotopes in British, Canadian, and US Gulf War Veterans*, 14 of 27 veterans suffering from the symptoms of the "unexplained" disease were proven to have been carrying depleted uranium in their tissues for the nine years since the end of the Gulf War.

In June 2002, the United States conducted bombing campaigns in Afghanistan as part of Operation Enduring Freedom. In the aftermath, UMRC twice dispatched field teams to investigate possible contamination of people and the environment. The significance of this initiative in unveiling the origin of the undiagnosed illness of the Gulf War must be noted. Afghanistan was a completely different environment from Iraq. Civilians there received no exposure to the pesticides, chemical warfare agents, biological warfare agents, vaccines, infectious diseases, oil-well fires and smoke — all these that had been named as possible etiological factors in Gulf War illness. Removing all these variables from consideration, the one common link that connected the battlefield of Iraq with the areas bombed in Afghanistan was US weapons.

The UMRC field team found Afghani civilians who had become ill after being exposed to the dust and debris from targets destroyed by aerial bombing. These individuals described symptoms that were identical to those described by veterans who had served in the Gulf. As described in the published articles and abstracts, these people were selected for study based on the presence of "fatigue, fever, musculoskeletal and neurological alterations, headaches and respiratory impairment." Urine specimens were collected from these individuals as well as from suitable controls and environmental samples were also gathered. The results of this research was presented in "The Quantitative Analysis of Uranium Isotopes in the Urine of Civilians after Operation Enduring Freedom in Jalalabad, Afghanistan" (Durakovic *et al*. 2003), "Internal Contamination with Uranium Isotopes after Operation Enduring Freedom in the Civilian Population of Jalalabad and Kabul, Afghanistan" (Durakovic *et al*. 2004), "The Urinary Concentration and Ratio of Uranium Isotopes in Civilians of the Bibi Mahro Region after Recent Military Operations in Eastern Afghanistan" (Durakovic *et al*. 2004), "The Analysis of the Uranium Isotopes Abundance and Ratios in the Civilian Population of Eastern Afghanistan as a Consequence of the Use of Radioactive Weapons in Operation Enduring Freedom (OEF)" (Durakovic *et al*. 2006). These studies presented a consistent picture. The test subjects had elevated concentrations of natural uranium in their urine up to 100 times higher than the normal range from var-

ious geographical and environmental areas throughout the world. Nowhere was depleted uranium detected. However, seven specimens from people living in Kabul were found to contain uranium-236, evidence that the uranium in the test subjects' bodies had been irradiated in a nuclear reactor. With uranium concentrations within the normal range for control subjects and environmental samples of soil and water, the implication was that the uranium contamination of the sick Afghanis came from US munitions.

When the second war in Iraq broke out in 2003, UMRC again sent field teams to investigate DU contamination. The results of one study was repeatedly reported in the *New York Daily News* and was later presented at the 33rd annual meeting of the European Society of Radiation Biology, 2004, under the title "Quantitative Analysis of the Concentration and Ratio of Uranium Isotopes in the US Military Personnel Deployed at Samawah, Iraq during Operation Iraqi Freedom" (Durakovic *et al*. 2004). This study involved nine US soldiers of the New York 442nd Military Police Unit. These individuals presented nonspecific symptoms of "headaches, fatigue, fever, musculoskeletal pains, respiratory impairment, neurological, and affect alterations." Laboratory analysis of urine samples clearly indicated that four of the soldiers were excreting depleted uranium.

One member of the 442nd was Herbert Reed. A newspaper article by Deborah Hastings in the *Honolulu Advertiser* reported some of Reed's experiences:

> Since he left a bombed-out train depot in Iraq, his gums bleed. There is more blood in his urine and stool. Bright light hurts his eyes. A tumor has been removed from his thyroid. Rashes erupt everywhere, itching so badly they seem to live inside his skin. His joints ache. Migraines cleave his skull.
>
> At Walter Reed Army Medical Center in Washington, D.C., he ran into a buddy from his unit. And another and another. They began to talk. "We all had migraines. We all felt sick," Reed says. "The doctors said, 'It's all in your head.'"
>
> "Then the medic from their unit showed up. He, too, was suffering. That made eight sick soldiers from the 442nd Military Police, an Army National Guard unit of mostly cops and correctional officers from the New York area. But the medic knew something the others didn't. Dutch marines had taken over the abandoned train depot, dubbed Camp Smitty, which was surrounded by tank skeletons and unexploded ordnance. They'd brought radiation-detection devices. The readings were so hot, the Dutch set up camp in the middle of the desert rather than live in the station ruins."

UMRC published a number of articles and abstracts of the test results conducted on urine and environmental samples collected after the initiation of the second war in Iraq. "Uranium Isotopes Bioassay in the Civilians of Baghdad and Al Basra after Operation Iraqi Freedom" (Durakovic *et al.* 2004) reports on a study of 15 sick Iraqi civilians, 10 from Baghdad and five from Al Basra. The most common symptoms reported by this cohort included "fatigue, intermittent fever, respiratory impairment, nocturnal diaphoresis, headaches, musculoskeletal pains, urinary tract impairment, and affect disorders." Lab tests determined that two subjects from Baghdad and three from Basra were contaminated with depleted uranium. Of added interest was the fact that eight of the 15 had a "significant presence" of uranium-236. No explanation was given in the study for why individuals who tested negative for DU nonetheless were carrying uranium-236 in their bodies.

At the 49th annual meeting of the Health Physics Society, UMRC presented "Concentration and Ratio of Uranium Isotopes in the Fine-Fraction of Surface Soil from Baghdad and Basra Collected after Operation Iraqi Freedom." In this study, 10 samples of surface soil collected from different sites in Baghdad, Basra and the Suweirah farming area were analyzed. The uranium concentration in the soil fine-fraction varied from about 1 to 2,600 mg/kg. All samples tested positive for DU and all were found contaminated with uranium-236. Different ratios of U^{238}/U^{235} and different concentrations of uranium-236 indicated that the DU that contaminated the tested soil originated from different stocks.

At the annual meeting of the Croatian Society of Nuclear Medicine in 2005, UMRC presented "The Bioassay of Uranium Isotopes in the Civilians of Baghdad and International Research Team Members after Operation Iraqi Freedom." This study included seven symptomatic civilians from the Baghdad area who had been exposed to aerial bombings and tank battles and three UMRC field team members. Test results confirmed that one Baghdad resident and all three representatives from UMRC were contaminated with DU. Three of the Baghdad samples and two from the research team also tested positive for uranium-236.

"Quantitative Analysis of Uranium Isotopes in the Civilians of Iraq after Operation Iraqi Freedom (OIF)" was a presentation delivered by UMRC to the 9th World Congress of the International Federation of Environmental Health in Dublin, Ireland, in June 2006. In this study, 22 symptomatic Iraqi civilians from Baghdad, Basra and Nasiriyah provided urine samples. Their reported symptoms included "headaches, fatigue, intermittent fever and affect disorders." Eight subjects tested positive for depleted uranium and all had detectable levels of uranium-236 in their urine. Of interest was the fact that three of the subjects who tested negative for DU were nonetheless excreting uranium-236.

UMRC also made a presentation in 2006 at the 9th Congress of the World Federation of Nuclear Medicine and Biology in Seoul, South Korea, entitled "The Analysis of the Uranium Isotopes Abundance and Ratios in the Civilian Population of Different Regions of Iraq as a Consequence of the Use of Radioactive Weapons in Gulf War II (Operation Iraqi Freedom, OIF)." This study involved seven symptomatic Iraqi civilians from Baghdad and 12 from Basra and Nasiriyah. One resident of Baghdad tested positive for DU. Three of the Baghdad samples also tested positive for uranium-236. Of the 12 test subjects from southern Iraq, five tested positive for DU and uranium-236. All of the subjects who tested negative for DU showed no evidence of contamination with uranium-236.

"The Quantitative Analysis of Uranium Isotopes in the Population of Port Hope, Ontario, Canada" was presented in October 2007 at the Annual Congress of the European Association of Nuclear Medicine. This study reported on uranium contamination of residents living near the uranium conversion facility in Port Hope, the oldest uranium-processing plant in the world. Urine samples were collected from individuals manifesting symptoms of musculoskeletal, central nervous system, immune system and neoplastic disease. The samples were analyzed, along with specimens from a suitable control population, for the presence and relative concentration of four uranium isotopes. Of nine samples collected from the study group, four contained uranium of nonnatural origin. One sample was highly positive for depleted uranium with a uranium-238 / uranium-235 ratio of 147.11 (plus or minus 1.42) with a relatively normal abundance of total uranium. This sample contained a concentration of uranium-236, indicating contamination by uranium which at one time had been present in a nuclear reactor. Likewise, three other samples contained detectable concentrations of uranium-236, once again of nonnatural origin. One of these samples contained higher than normal concentrations of total uranium amounting to 24.8 ng/L. (Background total uranium concentration in human urine is 7.0 ng/L.) The remaining five samples were negative for both depleted uranium and uranium-236. The conclusion of the study read as follows: "The history of uranium contamination of the vicinity of Port Hope has been verified in objective scientific literature. Our results suggest long-term contamination and possible adverse effects on the body burden of the current population of Port Hope. These preliminary results warrant additional multidisciplinary studies."

Presented with the evidence collected by UMRC, any rational individual would conclude that contamination with depleted and non-depleted uranium may be a factor in the undiagnosed illnesses of the radioactive battlefield. Large-scale testing of symptomatic individuals is urgently needed to determine the pervasiveness of uranium contamination among military forces and civilians in recent war zones. New research initiatives must be undertaken to determine the physiological effects of internalized battlefield uranium. But

the US government categorically ignores the scientific work of UMRC, continuing to reassure the world that DU weapons produce no collateral health damage. It must be stressed that the methodology of UMRC in analyzing human specimens and environmental samples is sound and scientific. Government-employed researchers have reproduced the procedures and confirmed its effectiveness in identifying DU contamination. (See "Determination of the Isotopic Composition of Uranium in Urine by Inductively Coupled Plasma Mass Spectrometry" by Ejnik *et al*. and "Detection of Depleted Uranium in Urine of Veterans from the 1991 Gulf War" by Gwiazda *et al*.)

Enemies of truth are attempting to control science and prevent humanity from awakening to the human and environmental hazards of weaponized uranium. Put simply: By their deeds, you will know them. A recent example reveals all.

In 2006, the Institute of Medicine published *Gulf War and Health. Volume 4: Health Effects of Serving in the Gulf War*. Upon publication, this work was heralded by many as the definitive word on the unexplained illnesses of the Gulf War. An editorial in *Mayo Clinic Proceedings* lauded the study, saying: "The latest IOM report is the product of an exhaustive assessment by well-respected experts in toxicology, occupational health, and numerous medical subspecialties and should, by rights, be the authoritative word on Gulf War illnesses" (Sartin). As revealed so many times within these pages, smoke-and-mirrors tactics are lurking everywhere.

The Preface of the Institute of Medicine study includes this quotation:

> Although there is a blood test that can provide an indication of exposure to Agent Orange and dioxin that occurred many years ago, there is not (sic) biological measure that can be employed today to assess exposures during the Gulf War.

It's hard to know what to make of this statement. It is either the product of shoddy research or intentional mischief, designed to contaminate people's minds with falsehood. In any case, it is a shamefaced lie. Indisputable evidence exists that depleted uranium leaves a signature within the body that can be detected by the analysis of the isotopes of uranium in urine. The work of UMRC reveals the liars for who they are.

Within the body of the text, the Institute of Medicine, pretending the inhalation pathway to internal contamination does not exist, shamelessly reveals its allegiance to US government propaganda with this blather:

> It should be recognized, however, that at the time of many of the large Gulf War cohort surveys, the potential for DU exposure (for example, involvement in a friendly-fire incident, rescue where DU-containing munitions or vehicles were used, or presence during a fire at Camp Doha, Kuwait, that involved detonation and burning of DU-containing munitions) was not as well understood as it is now. Consequently, veterans who reported their own DU exposure were working with the best available information and reported that they were exposed, whereas it is now understood that retention of DU-containing embedded shrapnel is the major source of increased DU exposure in military personnel.

Before all of mankind, the science produced by UMRC hurls the gauntlet at the feet of those who disperse uranium among human populations. If the only responses they can muster are glaring omissions and unsound, unscientific propaganda, this only serves to give further credence to the hypothesis that depleted uranium is a factor in the unexplained illnesses that are spreading with each new military incursion.

13

The Harlot of Babylon Unmasked: Fraudulent Science and the Cover-Up of the Health Effects of Depleted Uranium

Then one of the seven angels who had the seven bowls came and talked with me, saying to me, "Come, I will show you the judgment of the great harlot who sits on many waters, with whom the kings of the earth committed fornication, and the inhabitants of the earth were made drunk with the wine of her fornication."

Revelation 17:1-2

Depleted uranium is a fascinating topic of study. Turn over any facet of the subject and what scurries out from underneath into the light of day are lies and subterfuge, distortions of truth and scientific fraud. Why should this be? Are depleted uranium weapons of such military importance that their purveyors believe any mendacity is justified to ensure DU's continued acceptance for use on future battlefields? Is the United States attempting to conceal its culpability for ruining the health of its veterans? Are the potential costs of cleaning up contaminated environments in Afghanistan, Kosovo and Iraq, or offering financial compensation to the inhabitants of these nations, so staggering that the US will embrace any falsehood to avoid liability? A hundred such speculations can be entertained, and an element of truth is likely to be found within each one. But to believe that any or all of these partial explanations truly illuminates the cause of the rampant dishonesty and underhandedness that surrounds DU is to become ensnared by the very ruse one is trying

to apprehend. To attain a panoramic vision of the guile that impregnates the subject of depleted uranium, one needs to recognize that, by its very nature, everything about DU can be nothing other than duplicitous. Disingenuousness is an inherent property of DU, as intrinsic to it as its density or specific activity. This is not because of what DU is or what it does, but because of what it points to.

Depleted uranium is radioactive and a byproduct of the process of enrichment that creates fuel for nuclear weapons and reactors. Spawned from this disreputable heritage, its image has required careful doctoring by the same clandestine propaganda matrix that has given pardon to all other radiation releases into the environment. The importance of this public relations campaign to those who embrace nuclear weapons and reactors cannot be overstated. At all costs, depleted uranium cannot be allowed to be proven hazardous to health. If DU, which is weakly radioactive, produces disease, all other activities which release more highly radioactive nuclides into the environment will likewise be condemned as perilous to life. By introducing DU onto the battlefields of the world, the US is gambling with the public's acceptance of the entire nuclear industry.

Soon after depleted uranium weapons were imposed upon humanity during the First Gulf War, a group of prestigious organizations around the globe, ostensibly independently of one another, released reports attesting that militarized uranium posed neither a radiological nor heavy-metal hazard to human health. These "definitive" studies were represented to the public as unbiased and objective. But their unstated intention was out-and-out political propaganda. Admittedly, they all provide a wealth of interesting and informative data on previous types of human and animal exposure to uranium and the biological effects that were observed. But hidden amongst the words was a cunning, multifaceted agenda to accomplish the following: (1) attempt to control the perception of how uranium interacts with human biology, (2) define and delimit all future scientific investigation into the health effects of DU, (3) surreptitiously broadcast the message that depleted uranium weapons do not violate international humanitarian law because they produce neither unnecessary suffering nor indiscriminate effects, (4) implicitly advocate for the ongoing use of DU on the battlefield. Interestingly, all of these major scientific reviews were remarkably similar in their arguments and conclusions, almost as if written by a single hand operating under a cluster of pseudonyms. The writers of each started with the same premises— the ICRP model of radiation effects and non-germane research on uranium's heavy-metal toxicity — and unsurprisingly reached the same endpoint that depleted uranium weapons cause no damage to health, other than in destroying their targets. Careful analysis reveals that every one of these "authoritative" studies produced similar errors in their logic and questionable conclusions in their science. By their common stratagem for attesting to DU's innocence, the defenders of this toxic metal inadvertently revealed their com-

plicity in attempting to indoctrinate the entire world with false ideas of depleted uranium's effects.

Until the introduction of depleted uranium weapons into combat, the international Cohorts in Collusion had had an admirable track record. For over half a century, they successfully ran interference for the nuclear powers and the nuclear industry, diffusing concerns over nuclear pollution and the biological effects of low levels of internal emitters. Called upon to deflect criticism of depleted uranium, they set about creating the same type of disinformation campaign that had worked so splendidly in the past. What they failed to recognize was that the world had changed since the 1950s, and depleted uranium differed in significant ways from previous forms of radioactive contamination of the biosphere. Made incautious by their hubris, they were oblivious to the trap of their own devising which they were about to fall into. By gross miscalculation, they failed to realize that their old tricks would fail utterly in waylaying peoples' concerns about depleted uranium.

These Masters of Deceit, when fabricating lies about the health effects of DU, failed to take into account the many unique realities that accompanied the deployment of DU weapons. First of all, the environmental contamination created by DU was confined primarily around gunnery ranges and geographically well-defined theaters of war. The military's cavalier dispersion of DU created spatially defined laboratories ripe for future scientific investigation. Second, environmental dispersal of DU in battle occurred only during bombing campaigns and episodes of antitank warfare. Thus, the start of the contamination to a population and the duration of the most acute exposure could be localized in time. For the first time, combining points one and two, the basic spatial and temporal parameters, for what amounted to human radiation experiments, were an open book to the entire world. Third, soldiers and noncombatants who became ill subsequent to exposure to exploded DU munitions formed well-defined study groups and offered clear criteria for the selection of appropriate control groups. Fourth, DU contamination created an unprecedented event never before seen during the nuclear age. This was the first time that people and the environment were contaminated by a single radionuclide. This uniquely simplified the study of internal, low-level radiation effects in humans. Research scientists could not have envisioned more perfect laboratory conditions than that thoughtlessly created by the warmongers. Fifth, access to contaminated areas could not be controlled. The US was performing its radiation experiments in populated areas to which travelers had unrestricted access. Sixth, having unrestricted access to contaminated territories, researchers were free to collect environmental samples, interview victims and gather relevant biological samples for later diagnostic testing. Seventh, the conditions so far mentioned allowed researchers to derive accurate estimates of the chemical and radiation dosages received by the exposed victims. Such accuracy put a knife to much of the deviousness, examined in a previous

chapter, in dose "reconstruction." Eighth, the radioactivity of uranium created a resurgence of interest in the biological effects of low levels of internal emitters. Independent investigators, immune from such intimidation as the threat of job loss or salary cuts, were free to determine the direction of their own research. Ninth, a new generation of sophisticated, well-informed and well-educated citizens were standing on the sidelines witnessing the war crimes perpetrated by the US. They understood the implications of dumping radioactivity on populations, and they were capable of seeing through many of the lies put forth by government to cover up its misdeeds. And finally, the internet emerged as a potent adversary to the spread of fascist propaganda by creating a milieu for the worldwide sharing of uncensored information. For the first time since the introduction of nuclear weapons, an independent avenue existed for the rapid dissemination of the latest discoveries regarding DU contamination. Information that previously would have remained classified or hidden within obscure scientific journals, broke into the public domain. New research studies with controversial or unorthodox conclusions were set free from the tyranny of the scientific journal system and made available for analysis by a wider audience. In addition, people who believed themselves injured by depleted uranium exposure or witnesses of those who had been exposed used the internet to share their experiences. The numerous postings on the worldwide web created a body of anecdotal evidence that a real, common symptomatology was being shared by those who had been exposed to DU. These points, taken together, unintentionally spun the web the United States created for itself when it elected to incorporate DU into weapons of war. And it is this mesh that has entrapped it and the World Wide Web of Deceivers.

By being oblivious to these new realities, the Brotherhood of Bunco has brought catastrophe upon itself. A huge disparity has emerged between its many studies, which promulgate the idea that depleted uranium has no adverse health effects, and rapidly accumulating evidence that DU is in fact responsible, or at least a cofactor, for producing the many symptoms that have come to define Gulf War Illness or Balkan War Syndrome. Rather than fulfill their politically motivated objective of covering up that people are being sickened by exposure to depleted uranium, the "definitive" studies published in DU's defense have caused a light to be shown on the integrity and objectivity of the organizations that have authored these studies. What is about to be revealed is that the published defenses of DU's harmlessness are an open testament that an entrenched, international Cabal of Liars is authoring misleading scientific tracts in the guise of truth to control the minds of inquiring people with false ideas so no objection will be raised to the chemical/radiological warfare being waged wherever depleted uranium munitions are deployed.

Oh, persistent reader! These pages have taken you on an odyssey around the world. The circumnavigation of our subject has revealed numerous campaigns of deception and

charlatanism disguised as science. Their is global treachery at work to dissuade human minds from embracing the idea that radiation liberated into the environment is a hazard to health. Visiting Hiroshima and Nagasaki, we witnessed the birth of deception regarding radiation effects when Manhattan Project military personnel chose to fabricate lies to cover-up the atomic plague that was decimating the survivors of the bomb. We lingered in Japan and explored the corrupted science of the Hiroshima Life Span Study that forever skewed radiation research and radiation protection. A visit to Oak Ridge, Tennessee allowed us to explore the canyons of deception etched into society by the US Radiation Accident Registry. Overflying the Atomic Energy Commission in Washington, DC in the early 1950s, we glimpsed the pressing need to legitimize the safety of the nuclear industry which spawned the beginning of the modern radiation protection agencies. Further, we witnessed the AEC's sponsorship of human radiation experiments and the ongoing crusade of that organization to cover-up the effects of fallout on human health during the period of above-ground weapon testing. Dropping by the National Cancer Institute, we explored research, which by its design, hid the elevated incidence of breast cancer among women living downwind of nuclear reactors. A stopover in Great Britain permitted us to witness repeated, state-sponsored defiance of scientific evidence that nuclear pollution is creating leukemia in children. Sailing around the British Isles, we caught a glimpse of the intentional corruption of data in the Wales Cancer Registry. We sojourned to the ICRP, and spent a great deal of time deconstructing their bogus theory of radiation effects as it applies to low doses of internal emitters. While in the Ukraine at Chernobyl, we learned that Russian authorities forbade doctors from diagnosing leukemia among their patients. Touching down at numerous locations around the globe, we heard false prophets lie about the casualties of the Chernobyl disaster and grossly underestimate the physical suffering and life-destroying diseases produced in innocent victims in many parts of the world. Burrowing through numerous scientific journals, we were eyewitness to interesting examples of flawed research and intentional malfeasance designed to trivialize low-level radiation's degradation of health.

Ostensibly, the pilgrimage through these pages has been represented as an investigation into the health effects of depleted uranium. However, fitting to the topic, this expressed intention has itself been a ruse. What has been sought by these labors is to use the subject of depleted uranium as a means of unmasking the Great Harlot of Babylon. Science, infiltrated by a political agenda and corrupted, has been made whore to the kings of the earth. Bearing false testimony and confounding the public, it has served to preserve weapons of mass destruction and pave the way for future carnage and unbounded human suffering. Unprecedented human wickedness is being unmasked: a cabal of deceivers, masquerading as the guardians of human knowledge, committing intellectual treachery in service to the perpetuation of hideous weapon systems.

The numerous studies that portray DU as harmless give license to the US to defile the Earth. Some of the more prominent of these reports deserve mention. In the UK, the Royal Society published a two-part study entitled *The Health Hazards of Depleted Uranium Munitions*. The World Health Organization authored *Depleted Uranium: Sources, Exposure and Health Effects*. A paper prepared for the European Parliament was written under the title *Depleted Uranium: Environmental and Health Effects in the Gulf War, Bosnia and Kosovo*. The European Commission published *Opinion of the Group of Experts Established According to Article 31 of the Euratom Treaty: Depleted Uranium*. In the United States, the Rand Corporation penned numerous volumes addressing the possible causes of Gulf War illness, including *A Review of the Scientific Literature as it Pertains to Gulf War Illnesses: Volume 7 - Depleted Uranium*. The Agency for Toxic Substances and Disease Registry, under the auspices of the US Department of Health and Human Services, published a lengthy study entitled *Toxicological Profile for Uranium*. The National Research Council sponsored a work entitled *Review of Toxicologic and Radiologic Risks to Military Personnel from Exposure to Depleted Uranium During and After Combat*. *Environmental Exposure Report: Depleted Uranium in the Gulf* was written for the Department of Defense. The US Army Environmental Policy Institute published *Health and Environmental Consequences of Depleted Uranium Use in the US Army*. In addition to these studies, a number of fact sheets, abstracts and summarizations of DU's effects can be found on the internet sites of the publishers of these studies as well as the sites of such reputable organizations as the International Atomic Energy Agency, NATO, the Health Protection Agency, the UK Ministry of Defense, the Depleted Uranium Oversight Board, the Canadian Army, the US Department of Veterans Affairs, the Environmental Protection Agency, the Health Physics Society, and on and on and on.

A casual inquirer stumbling upon this impressive body of work might easily come under its sway, believing that it is the expression of complete, up-to-date, truthful, unbiased, objective information. How could he think otherwise? The reputation of the aforementioned institutions bestows instant credibility and unquestionable impeccability to their every word. Standing before their unimpeachable wisdom, critics of DU weaponry are meant to be disarmed. To utter one word that blasphemes S C I E N C E is to declare oneself an apostate of rationality, a renegade of the twenty-first century, an uninformed and opinionated rabble-rouser.

The studies mentioned unambiguously affirm that DU does not injure those exposed to it. A few quotations, representative of the whole body of literature, will illustrate their point of view.

The European Parliament study had this to say in its final statement and recommendations:

> - Having comprehensively reviewed and cross-examined most of the specialized scientific literature, in particular the medical literature, judged reliable and trustworthy,
> - Having in mind the results provided by the medical observation over decades of workers of the uranium industry as well as by the experiments with animals,
> - Taking into account the results of the recent investigations in Iraq and in the Balkans of the effects on man and on the environ ment following the use of DU,
>
> the report concludes that the use of DU-ammunition in Iraq and the Balkans neither has led to a serious widespread contamination of the environment nor represents an acute or appreciable long-term hazard for man's health.

The US Armed Forces Radiobiology Research Institute, in one of its publications, offers this reassurance:

> "DU is neither a radiological nor chemical threat" (Jarrett).

Typifying the smugness, feigned omniscience and intellectual imperialism of the defenders of depleted uranium is this statement found on the website of the Health Physics Society:

> Answer to Question #746 Submitted to "Ask the Experts"
>
> Q: How are bullets made by depleted uranium, and what reactions do they cause when they enter into contact with the ground and with humans?
>
> A: Because of its very high density — nearly twice that of lead — and certain other properties, depleted uranium is used in certain kinds of munitions because of its ability to penetrate heavily armored vehicles such as tanks and armored personnel carriers. Depleted uranium (DU) is not used in small cartridges or bullets for rifles or machines guns but alloyed DU is used in the 25, 105, and 120 millimeter (mm) kinetic energy cartridges used primarily as antitank munitions. DU is also a component in some tank armor and sometimes used as a catalyst for land mine systems.
>
> Since depleted uranium is weakly radioactive, the public has been concerned about the possibility of adverse health effects from DU. DU is a heavy metal, and like all heavy metals such as mercury and

lead is toxic. However, except in certain very unusual situations, it is the chemical toxicity and not the radioactivity that is of concern. And, from a chemical toxicity standpoint, uranium is on the same order of toxicity as lead. Largely from work with animals along with a few instances in which humans inhaled very large amounts of uranium, the chemical toxicity of uranium is known to produce minor effects on the kidney, which in humans who have suffered large acute exposures have been transitory and wholly reversible. Because depleted and natural uranium are only weakly radioactive, radiological effects from ingested or inhaled uranium have not been detected in humans.

Human experience with uranium has spanned more than 200 years.. In the early part of the twentieth century, uranium was used therapeutically as a treatment for diabetes, and persons so treated were administered relatively large amounts of uranium by mouth. Tens of thousands of persons have worked in the uranium industry over the past several decades, and have been followed up and studied extensively as have populations in Canada and elsewhere who have high levels of uranium in their drinking water. Results of these studies have not revealed any ill health in these populations that is attributable to the intake of uranium. This is not surprising, as the risk from the radiation dose from uranium is far overshadowed by its potential chemical toxicity, and intakes of uranium of sufficient magnitude to produce chemotoxic effects are unlikely in and of themselves. Any such effects from ingestion or inhalation of uranium would likely manifest themselves first in the form of minor effects associated with the kidneys. That military personnel and others who may have had contact with depleted uranium from munitions are suffering from various illnesses is not in dispute. That their illnesses are attributable to their exposure to uranium is very, very unlikely. Health physicists are deeply concerned with the public health and welfare, and as experts in radiation and its effects on people and the environment, are quite aware that something other than exposure to uranium is the cause of the illnesses suffered by those who have had contact with depleted uranium from munitions. A truly enormous body of scientific data shows that **it is virtually impossible for uranium to be the cause of their illnesses** [emphasis added]. Despite this body of scientific data to the contrary, misguided or unknowing people continue to allege that the depleted uranium, and specifically the radioactivity associated with the depleted uranium is the cause of these illness. This is indeed unfortunate, for health physicists and other scientists

> and physicians already know that depleted uranium is not the cause of these illnesses and thus any investigations into the cause of these illnesses should focus on other possible causes.
>
> If we are to offer any measure of relief or solace to these suffering people, and to gain some important additional knowledge of the cause of their illness, we should not waste our valuable and limited energies, resources, and time attempting to point the finger at depleted uranium as the culprit, when it is already known that uranium is almost certainly not the cause of the problem. With respect to reactions with the soil, in time depleted uranium will likely leach into the soil and become mixed with it. It will for all practical purposes be chemically indistinguishable from the natural uranium that is already present in the soil all over the earth. One could create all kinds of scenarios, but probably the best way to think about DU in the soil is to compare it with lead. Because lead and uranium are so similar from a toxicological standpoint, the concerns are about the same.
>
> Ronald L. Kathren, CHP
> Professor Emeritus Washington State University

The texts defending DU are in remarkable harmony with each other. Their authors and defenders will assert that this consensus of opinion is no surprise, since it is an expression of indisputable, scientifically verified TRUTH. End Of Argument!!! However, when one begins to dig below the surface and review the substantial body of research that DU munitions have spawned, an entirely different picture emerges from that portrayed in the scholarly scientific papers mentioned previously. This casts the objectivity and completeness of their conclusions in doubt. Further, it raises the embarrassing question of how all the official reports can appear so similar while the jury is still deliberating over the final verdict of DU's effects. In light of this new body of knowledge, the apparent consensus of the so-called experts seems contrived. Their united front is not an expression of the current state of knowledge of DU's effects, but rather, yet again, a sophisticated beguilement intended to sabotage open-minded understanding of the inhumane devastation created by modern weapon systems. The State Ministry of Enlightenment and Propaganda did not die with the Third Reich but remains very much alive in the New World Order.

In a presentation to the European Parliament in 2005, Keith Baverstock, an expert on the subject of environmental and occupational exposure to ionizing radiation, provided these telling observations:

> A number of organizations, including the World Health Organization, the International Atomic Energy Agency, the UK Royal Society, the International Commission on Radiological Protection and the European Commission Article 31 Group have, since 2001, published advice relating to the health consequences of exposure to DU. **You may wonder, as I do, how such authoritative and independent organizations, making ostensibly "independent" assessments of the situation can all ignore the evidence that exists in the scientific literature** (emphasis added).
>
> It is worth noting that these assessments may not in fact be truly independent. For example, staff of the UK National Radiological Protection Board (NRPB) are acknowledged as contributing to the WHO and RS reports, the Chairman of the ICRP was recently the Director of the NRPB. Staff members of the NRPB collaborate with the IAEA and have been members of the Article 31 Group. It is, therefore, possible that a few individuals have influenced the outcome of these so-called independent assessments.

This observation should not be passed over lightly. It is a bombshell, demonstrating how easily the game can be rigged.

Baverstock continues:

> For me, as a scientist, it is the fact that this evidence [of DU effects in the scientific literature] is IGNORED, as opposed to being ADDRESSED, and if appropriate discredited, through rational scientific debate that is worrying. Science is about a reality that overrides political expediency. Ignoring the evidence does not mitigate the health consequences of exposure to DU and not looking for the consequences does not mean they do not exist. Mark Danner (Danner 2005), writing in the New York Review of Books recently, detects a currently resurgent belief that "Power [political power] can shape truth: power in the end can determine reality, or at least the reality that most people will accept." He further notes that this was stated rather directly by the "last century's most innovative authority on power," Joseph Goebbels.
>
> I am on record (Baverstock, April 2005) as saying that "politics has poisoned the well from which democracy must drink." By this I mean that political expediency has all but eliminated truly independent research and along with that went PUBLIC TRUST. Without public

> TRUST democracy cannot work. In the context of risk assessment SCIENCE should provide the evidence, openly and transparently, and unalloyed with any interest in the outcome except that it be the truth. On the basis of this evidence POLITICS should decide the risk that is acceptable within the social and legal context of the time.

At the outset for all that follows, it must be emphasized that there is no falsehood in any of the information contained in the studies mentioned above. None of them are guilty of committing sins of commission. Their sly deception is delivered by what they withhold. Thus, they are guilty of sins of omission. By means of what they leave unsaid, crimes against humankind are perpetuated.

A smokescreen of global proportions has been created to coverup the link between DU and the illnesses it produces. Fortunately, it is a lot less sophisticated than that for low-level radiation effects from internal emitters that we reviewed previously. The basic features of this stratagem of beguilement can be concisely characterized. The works that find DU biologically benign all make mention at some point that very little research has actually been conducted on DU's effect on human health. Consequently, now watch the card being sloughed under the table, they divert their discussion from DU's effects to a discussion about the effects to health of natural and enriched uranium. The justification given for this divergence may at first sound perfectly reasonable. Given that all isotopes of uranium are chemically identical, their chemical effects to the body as a heavy metal will be identical, and since DU is less radioactive than either natural or enriched uranium, the radiological effects it produces in the body will be correspondingly less significant. On the basis of this logic, some kind of review is then made of the large body of existing research on the medical consequences of uranium exposure to such groups as uranium miners, uranium millers, workers within the nuclear industry, and populations whose drinking water was found to contain inordinately high levels of uranium. By using as a means of comparison exposure scenarios that have only limited relevance to DU exposure, the possible medical effects of battlefield DU are circumscribed: kidney damage due to uranium's chemical characteristics or cancer due to uranium's radioactivity. Having craftily defined the *only* possible medical effects of DU in doses likely to be encountered on the battlefield, the observation is then made that, with few exceptions, sick veterans are not manifesting any signs of kidney disease. Furthermore, the *dose* of radiation, according to the ICRP, is too small to induce cancer. Although Gulf War Syndrome has nothing to do with kidney disease or, at least so far, cancer, the conclusion is nonetheless resoundingly proclaimed that depleted uranium cannot be the cause of veterans' illnesses. Case closed! Battlefield uranium does not cause collateral damage to human health or the environment.

In this shell game, it is important to keep your eye on the pea. There are a number

of questionable assumptions that are being passed off as indisputable fact. First, is the body of past research on uranium exposure relevant to an understanding of DU exposure? Second, do aerosolized particles of DU behave the same way once inside the body as particles of uranium found in nature and industry? Third, is it reasonable to conclude that the only biological effects expected from exposure to depleted uranium will be kidney damage or cancer? Fourth, does the fact that Gulf War veterans are not manifesting these pathologies substantiate the argument that DU is not a cause or a contributor to their illnesses?

All claims that depleted uranium produces no harm rely on the same fundamental premise: exposure to depleted uranium aerosols on the battlefield is no different from exposure to the uranium found in nature or industry. This foundational *assumption* has never been validated by objective scientific research. This needs repeating: **This foundational *assumption* has never been validated by objective scientific research**. It is mere conjecture, originating either from confused and uncritical thinking or from the desire to obfuscate the subject matter. Attention must be focused at this point, for it is here where the breach in the wall can be found for all claims that DU is benign. Here the magician fumbles his trick and his tomfoolery is revealed. Hidden within one sleeve is the fact that relevant, widespread epidemiological studies on populations exposed to DU are not being conducted. Hidden in the other sleeve is the fact that the evidence that DU is innocuous consists of nothing more than repeated references, looping over and over again, to outdated and irrelevant research on occupational exposure to natural uranium. The studies which have determined that DU poses no risk to health base their conclusions on literature searches of published research on uranium's toxicity. What they conveniently fail to confess is that the database of existing studies contains little pertinent information on uranium's toxicity in the form in which it is delivered to the body by DU weapons.

From a toxicological point of view, the thesis that battlefield DU produces effects analogous to that produced by natural uranium in the workplace requires a reasonable correlation between the two. Specifically, for the kinetics and biochemistry to be the same once inside the body, particles of natural uranium and particles of DU would need to share similar physical characteristics, share a similar chemical composition and be of similar size. A little reflection will reveal that, on all counts, this is most certainly not the case.

To understand the uniqueness of depleted uranium as an internal contaminant, a rudimentary understanding is required of what happens to uranium once inside the body. In regards to inhaled uranium particles, their kinetics is primarily determined by their size and their solubility. Particle size is the fundamental determiner of the region within the respiratory system where particles are deposited, their residency time and their access to the systemic circulation. For inhaled particles to be absorbed into the bloodstream, they first

must be drawn deep enough into the lung to reach the non-ciliated portion of the bronchial tree, enter the micro-bronchial compartments and make contact with the alveolar surfaces. Particles able to penetrate this region are termed "respirable" and are less than 10 microns in diameter. Particles larger that 10 microns in diameter are non-respirable. Either they are immediately exhaled or they become trapped in the ciliated portion of the bronchial tree where they are then translocated to the nasopharynx by mucociliary action, swallowed and eliminated via the gastrointestinal tract (with perhaps a tiny fraction being absorbed in the gut.)

Although uranium miners and mill workers are continually exposed to dust particles containing uranium, the hazard from their exposure is lessened due to the fact that the average size of the particles is too large. Most of the dust commonly inhaled in uranium mines and mills is non-respirable and never reaches the alveolar region. For the most part, its residency time within the lungs is relatively short. One study of uranium workers exposed to high levels of uranium dust confirmed very low lung burdens of uranium, indicating that only a small fraction of the dust penetrated into the alveolar region and remained there. The remainder was cleared from the lungs either via retrograde tracheobronchial mucus transport to the gastrointestinal tract, scavenging by macrophages into the lymph nodes, or dissolving of the soluble fraction followed by absorption at the alveoli into the circulating blood (West and Scott).

To create a sense of the biokinetics of inhaled natural uranium, the ICRP has produced a model that is widely referenced. A summary of this can be found in the RAND Report:

> Very little of the amount of natural uranium that is inhaled eventually reaches the kidney. This is because the body is amazingly efficient at clearing alien substances through a variety of mechanisms. Of the natural uranium inhaled, 75 percent is exhaled and only 25 percent is retained in the lungs. Of the 25 percent uranium initially retained in the lungs, 80 percent is cleared by the bronchial mucociliary mechanism, which results in most of the natural uranium finding its way to the GI tract where most is excreted and only a fraction enters the bloodstream. Of the 20 percent deposited in the lungs that is not cleared by the mucociliary action, 15 percent ends up in the lymph nodes for a long period and 5 percent enters the blood (either directly from the lungs or from the GI tract or lymph system.) Then of the original 100 percent of natural uranium that entered the body via inhalation, less than 1 percent eventually makes its way to the kidney, where it might affect renal function.

In contrast to natural uranium where only a small percentage of particles are respirable, aerosolized DU contains a much higher percentage of such particles. Impact studies of DU penetrators have revealed that anywhere from 0.9% to 70% of the debris becomes airborne (Chambers *et al.*). Of this material, a majority of the particles produced are respirable. Near the end of the chapter entitled *A Short History of Radiological Warfare*, a chart is reproduced depicting findings by Glissmeyer and colleagues about the particles formed by the incineration of DU ammunition and penetrators. According to this study, more than 73% of the particles produced were respirable. Referencing a different study, the RAND Report includes this information: "For particles generated by fire, the percentage smaller than 10 micron aerodynamic equivalent diameter (AED) ranges from 0.1 to 33, while particles generated from impact of a hard target are virtually all smaller than 10 micron AED" (USArmy CHPPM).

For that fraction of inhaled particles small enough to reach the alveoli of the lung, their rate of absorption into the systemic circulation is determined by their solubility. This solubility is primarily a function of the physical characteristics of the particles and the molecular composition of the compounds to which the uranium is bound. According to a model formulated by the ICRP (1996), the range of uranium compounds can be classified into three distinct groups according to their solubility. Type F (fast dissolution) particles have a residency time that can be measured in days. Type M (medium dissolution) particles have a residency time of weeks. Type S (slow dissolution) particles might remain in the lung for years. The uranium dissolving out from the small particles in proximity to the alveoli is most commonly in the form of the uranyl ion (UO_2^{++}) and available for rapid absorption into the systemic circulation. Once released into body fluids, the uranyl ion becomes complexed with anions such as citrate and bicarbonate or bound to albumin or proteins (Diamond 1989; Kocher 1989; Leggett 1989). As referenced in an article by Bertell (2000): "The soluble fraction of uranium which passes the lung-blood barrier, is expected to form chemical complexes with the bicarbonate in plasma (47%), form chemical bonds with protein in plasma (32%), and bind to the red blood cells interfering with iron transport (20%) (Chevari and Likhner)." A large fraction of soluble uranium remains highly mobile within the body and is considered toxic due to its chemical effects. By contrast, insoluble uranium present deep within the lungs is immobile and exerts a toxic effect to surrounding cells by its radioactivity.

The three most predominant compounds of uranium encountered by nuclear workers are triuranium octaoxide (U_3O_8), uranium dioxide (UO_2) and uranium trioxide (UO_3). Of those exposed to depleted uranium aerosols, some fraction of the uranium to which they are exposed is of the same three forms. *It is for this fraction only where a comparison of natural uranium to DU is valid*. UO_3 is of intermediate solubility while both U_3O_8 and UO_2 are

highly insoluble. Soluble particles in proximity to the alveoli will rapidly dissolve, permitting uranium to enter the circulation. Structural or functional damage to the kidneys from accidents involving the inhalation of inordinately high levels of uranium result from exposure to highly soluble compounds of uranium. The rapid influx of uranium into the blood is effectively excreted by the kidneys, but damage can be produced by the accumulation of uranium in the epithelium of the renal tubules. This induces cellular necrosis and atrophy in the tubular walls. The result is the decreased reabsorption efficiency of biologically useful molecules which are then excreted in the urine. Urinalysis provides an easy diagnostic tool for monitoring altered kidney function.

Of the soluble uranium that enters the bloodstream, 67 percent is rapidly excreted by the kidneys from the blood either directly or after a short period of retention within the epithelial cells of the renal tubules. Normal levels of uranium excreted in urine range from 0.04 to 0.5 micrograms per liter. The uranium not immediately excreted or retained in the kidney is deposited in other tissues of the body, most predominantly in the skeleton and in the liver, but all tissues of the body may receive trace quantities. The normal body burden of uranium in human beings is approximately 90 micrograms. Approximately 66 percent of this total is bound in the skeleton, 16 percent resides in the liver, eight percent can be found in the tissue of the kidneys and 10 percent is distributed throughout the body's other tissues.

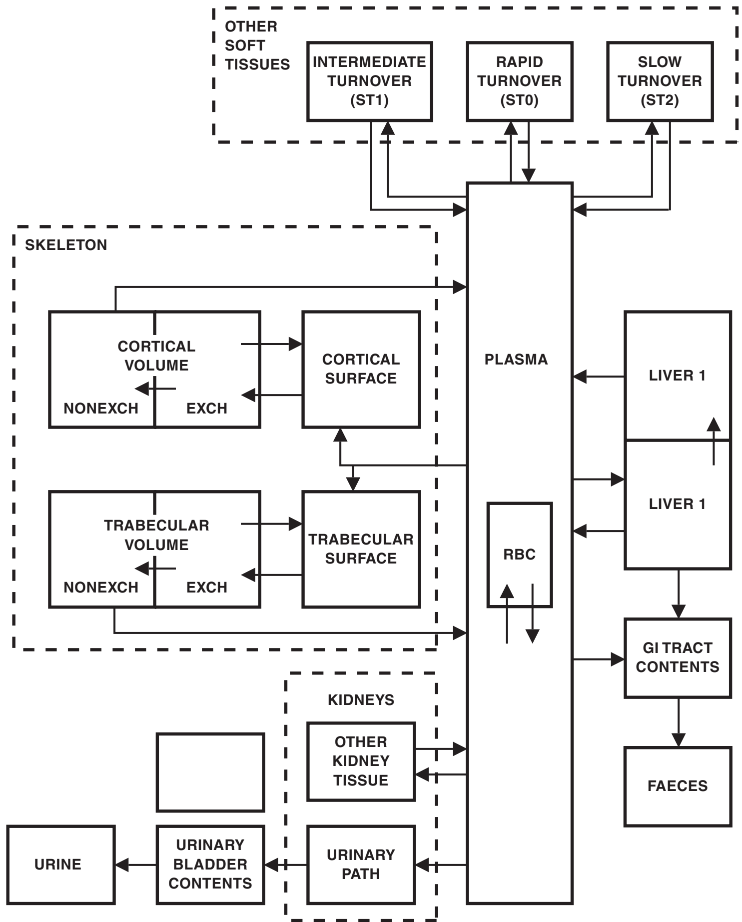
The affinity of uranium for the skeleton deserves special mention:

> Bone is a major site of uranium deposition. Neuman and colleagues, in a series of early articles designed to understand how uranium interacts with normal bone metabolism, published the first observation demonstrating that bone has a high affinity for uranium. Twenty to 30 percent of a toxic does of intravenous uranium could be found in the bones of male rats within 2.5 hours after administration, and 90% of the uranium retained by the body after 40 days was in bone [Neuman 1948a]. They showed that young growing rats or rats deficient in dietary calcium incorporated greater amounts of uranium than controls [Neuman 1948b]. They also showed that uranium is preferentially incorporated in areas of active calcification and becomes more refractory to resorption as new calcification covers areas of uranium deposition [Neuman 1948c].
>
> Uranium incorporates itself into the bone matrix by displacing calcium to form complexes with phosphate groups in the matrix [Domingo 1992; Guglielmotti 1989]. Bone-bound uranium establishes a equilibrium with uranium in the blood, and as the circulating ura-

> nium is excreted by the kidneys, bone-bound uranium slowly returns it to the circulation over time [Wrenn 1985]. Pellmar *et al*. [Pellmar 1999a] demonstrated that DU from implanted pellets rapidly distributes throughout the body and accumulates at high levels in the bone, though histological examination showed no bone lesions as a result.

The biokinetics of that fraction of uranium not immediately excreted by the kidneys is dynamic and quite complex. For purposes of illustration, the following diagram is reproduced from "The Biokinetics of Uranium Migrating from Embedded DU Fragments" (Leggett and Pellmar). It is based on a model adopted by the ICRP. Uranium in the blood is distributed to various tissues where it is retained for variable lengths of time. Once deposited in an organ of retention, it can be transferred to other areas within that organ or re-released into the bloodstream. This uranium may be absorbed by another target organ or remain in the blood to be excreted in the urine. The WHO explains the workings of this model as follows:

> The model assigns 30% to soft tissues (rapid turnover, ST0), this represents a pool of activity distributed throughout the body which exchanges rapidly with the bloodstream. The remaining activity is apportioned as follows, kidneys 12%, liver 2%, bone 15%, red blood cells 1%, soft tissue (intermediate turnover, ST1) 6.7%, soft tissue (slow turnover, ST2) 0.3%, with 63% being promptly excreted in urine via the bladder.
>
> Some of the material initially deposited in these regions can be returned to the blood stream while some is transferred to other regions of tissues. For example, material in the soft tissue compartments is returned only to blood while material in liver can be exchanged with blood or transferred to other regions of the liver (Liver 2). The bone warrants additional comment. Material is initially deposited on the bone surface (either trabecular or cortical), from where it can be transferred to bone volume (exchangeable) or returned to the bloodstream. Material which does reach the exchangeable bone volume can be buried deeper in the bone volume (non-exchangeable) or returned to the surface. Material in non-exchangeable volume is transferred slowly to blood. In time, most of the systemic uranium is excreted in urine via the bladder, a small fraction is also excreted in feces.
>
> The length of time that material remains in these regions is partly governed by a removal half-time, i.e. the time that it takes to remove



Structure of the Biokinetic Model for Uranium in Humans (Leggett 1994; ICRP 1995).

half of the material present. This time varies from organ to organ, for example the removal half-time for ST0 is as little as two hours, while for ST2 it is one hundred years. The net or apparent time that it takes to halve the amount of material in an organ, however, can be very different from the removal half-time, since material is continually being redeposited by the recycling nature of the model. The net half-time thus results from a combination of removal of existing material and deposition of new material from the blood stream.

Inhaled insoluble particles of uranium small enough to reach the non-ciliated portion of the bronchial tree and the alveoli remain relatively immobile. Uranium dissolves in

body fluids, so soluble particles are continually created and become free to be absorbed into the bloodstream. Due to their potentially long residency time in the lung, insoluble particles of uranium are thought to be primarily a radiation hazard to lung tissue. One study simulating DU's dissolution properties in internal human lung secretions concluded that the shortest possible dissolution half-life is slightly less than four years (Mishima *et al.*). While retained in the lung, insoluble particles can be engulfed by macrophages. These can transport insoluble particles to areas in the bronchial tree where they can be removed by mucociliary action or they can transport them for deposit in the pulmonary or tracheobronchial lymph nodes. There are two points worthy of mention regarding the insoluble fraction of uranium deposited in the lungs. First, due to gradual dissolving, insoluble uranium is not considered a hazard to the kidneys. Insoluble particles slowly dissolving in the lung do not flood the bloodstream with sufficient concentrations of uranium to pose an acute or chronic toxic threat to kidney structure or function. Second, those exposed to DU on the battlefield inhale both a soluble fraction and an insoluble fraction. Most of this soluble uranium will be excreted from the body in a short period of time. Under battlefield conditions, veterans who inhale DU aerosols may manifest evidence of elevated uranium in the urine if tested within days or weeks of exposure while the body is clearing the soluble portion. However, this type of testing is not routine. Testing for total uranium in urine months or years after exposure is a worthless test for providing any information of inhalation exposure to depleted uranium. By that time, the concentration of uranium in urine will have returned to within normal levels, and no information will be provided concerning the quantity of *insoluble* uranium particles retained within the body.

It is important to recognize that significant kidney damage will only occur when high levels of sufficiently small particles of *soluble* uranium are inhaled during a very short period of time. According to the *Toxicological Profile of Uranium*:

> In animals, kidney damage is the principal toxic effect of uranium, especially to its soluble compounds. The kidneys have been identified as the most sensitive target of uranium toxicosis, consistent with the metallotoxic action of a heavy metal. The toxic action is mediated by accumulation of uranium in the renal tubular epithelium which induces cellular necrosis and atrophy in the tubular wall resulting in decreased reabsorption efficiency in the renal tubule in humans and animals. Heavy metal ions, such as uranyl ions, are also effective in delaying or blocking the cell division process, thereby magnifying the effects of cell necrosis. These renal effects observed in animals can also occur in humans if the uranium dose is high enough. However, these effects have only been seen in certain acute poisoning incidents in humans (ATSDR).

Depending on exposure parameters, morphological changes to the kidney from uranium can range from microscopic lesions in the renal tubular epithelium to cell necrosis. Renal dysfunction will be detectable by elevated levels in the urine of, among other things, proteins and amino acids due to the failure of reabsorption of these molecules in the renal tubules. Studies have confirmed that regeneration of damaged cells does occur. Tissue having undergone minor lesions may be repaired to such an extent that it appears indistinguishable from undamaged kidney tissue. Repair of more severely damaged tissue will leave signs of the previous damage with cells of markedly altered structure. Animal studies and some human studies show that tolerance to structural and functional alterations can develop from repeated exposure. According to the Royal Society:

> However, there is evidence from animal studies that chronic exposure leads to an increased tolerance to the nephrotoxic effects of uranium (Leggett 1989). This effect was apparent in rats with implants of DU pellets where no histological or functional signs of kidney damage were apparent, although the measured levels of uranium in the kidney were greater than those that are known to be nephrotoxic after acute intakes (Pellmar *et al*. 1999). The lack of any signs of kidney dysfunction in the soldiers with retained DU shrapnel needs to be treated with caution as animal studies indicate that apparent tolerance to uranium still results in alterations in kidney histology (Leggett 1989), and an increased chance of kidney dysfunction in later life among these veterans cannot be ruled out.

In their article *Radiological Toxicity of DU*, Baverstock, Mothersill and Thorne provide an excellent overview of uranium's toxic effects on the kidney:

> In body fluids, the main form of uranium is thought to be the uranyl ion, UO_2^{++} (Leggett 1989). However, in the blood plasma approximately 40% of uranium is present as transferrin complexes and 60% as low molecular weight anionic complexes. These low molecular weight anionic complexes are filtered rapidly by the glomerulus and enter the lumen of the kidney tubule. The rapidity of this process may be illustrated by noting that, in the first 24 hours after entry of uranium nitrate into the systemic circulation, around 80% will have been filtered by the glomerulus (Leggett 1989).
>
> As the filtered uranium complexes pass along the renal tubules they are subject to a fall in pH. This results in their partial dissociation. Whereas some complexed uranium plus a proportion of the uranyl ions produced on dissociation is excreted in the urine, the remainder

of the uranium binds to the luminal membranes of the renal tubules. The bound uranium is removed from the luminal membranes by combining with ligands in the urine, shedding of microvilli, sloughing of dead cells, or entering cells. The rate of loss by each of these processes is thought to be dependent on the magnitude of the exposure to uranium, such that the fraction of uranium retained in the kidneys increases with increasing administered amount (Leggett 1989).

It is thought that the mode of entry of uranium into renal tubule cells may be primarily by endocytosis. Intracellular accumulation is mainly in lysosomes, with microcrystals formed at high concentrations. Destruction of the lysosomes then releases these microcrystals into the cytosol.

Although intracellular uptake is primarily into lysosomes, smaller amounts of uranium accumulate in the nucleus, mitochondria and other intracellular organelles. (Leggett 1989)

Overall, uranium-containing debris may be retained for an extended period in the lumen of the tubule or in reticuloendothelial cells.

Retention of uranium in the kidney is known to give rise to a variety of biochemical effects that may have implications for the clinical toxicity of the element (Leggett 1989). These include the following:

* Binding to the brush-border membrane may reduce reabsorption of sodium, glucose, proteins, amino acids, water and other substances;
* Structural damage to plasma and lysosomal membranes may occur, the latter resulting in the release of damaging enzymes;
* Mitochondrial dysfunction and defects of energy production may occur;
* Transport of calcium may be affected, leading to accumulation of that element in renal tubule cells.

At an overall tissue level, the kidney may develop tolerance to uranium exposure after repeated or chronic exposure, but this is associated with regenerated cells with a degraded brush border. Impairment of function can be associated with such tolerance. For example, tolerant animals have been observed to exhibit high urine volumes and a diminished glomerular filtration rate. It has been concluded that acquired tolerance to acute effects does not prevent chronic damage. (Leggett 1989)

> Conventionally, it has been assumed that if kidney concentrations of uranium are maintained at less than 3 É g/g, symptoms of clinical toxicity will be avoided. However, this limiting concentration was based on tests of limited sensitivity and on criteria for toxicity that are less stringent than would now be employed. In view of these considerations, it has been suggested (Leggett 1989) that it may be prudent to lower this long-standing level by one order of magnitude.

The metabolic pathways of internalized uranium have been extensively researched. On this point, one would not expect to encounter mischief. And yet, even here, mischief is afoot. Research sponsored by Canada's Department of National Defense makes the claim that isotope analysis by mass spectrometry of hair samples, and a determination of the ratio between isotopes, can accurately identify people exposed to depleted uranium (Ough 2002). This is utter nonsense. Hair is not a metabolic endpoint for internalized uranium. Further, hair is easily contaminated with the uranium found in nature from hair products and water supplies. Uranium from these sources will hopelessly corrupt the accurate assessment of isotopic ratios present within hair. Hair analysis will deliver meaningless data as to whether or not a person has received exposure to DU. Such scientific fraud is not an isolated case. The International Coalition to Ban Uranium Weapons is sponsoring the Iraqi Children's Tooth Project. Researchers for this study have collected teeth from children living in areas in Iraq contaminated with uranium weapons. They plan to analyze the ratio of uranium isotopes present within these teeth and compare them to the teeth of children living in the United States and Canada and to teeth recovered from archeological digs of people who lived prior to the dawn of the nuclear age. As noble as this initiative sounds, it is garbage science. The dentine of teeth absorbs uranium from the blood, but tooth enamel absorbs uranium from the external environment. The concentration of uranium in teeth will be influenced by the uranium present in air, food and water. As for archeological samples, teeth absorb uranium from the medium in which they are buried as they fossilize (Skinner *et al.*). As a consequence of these processes, the analysis of uranium isotopes in teeth cannot possibly deliver an accurate picture of DU contamination. Isotope ratios will be totally bastardized by non-DU sources of uranium rendering any conclusions of DU exposure meaningless. Readers are encouraged to follow this study as it progresses in order to witness the unfolding of the hidden agenda being sought by this junk science. And oh, donations for the Iraqi Children's Teeth Project can be made at www.bandepleteduranium.org.

The Rand Report repeatedly reminds the reader that the radiation emitted by depleted uranium is forty percent less than that of natural uranium, and that consequently, natural uranium poses the greater radiological hazard. There is an element of deception built into this reasoning. In the case of uranium miners, the radiological hazard to

which they are exposed from uranium is a lot *less* hazardous than for those exposed to microscopic particles of DU. Under most geological conditions where uranium is found, it is present in low concentrations. One ton of ore typically contains only one to four pounds of uranium oxide (0.05 to 0.20 percent). Thus, for the most part, the dust particles inhaled by miners are not concentrated uranium. They are a blend of uranium intermixed with molecules of the various minerals with which it is found. Due to the rapid clearance of the majority of dust particles inhaled by miners, either because of particle size or solubility, the radiation imparted to the internal environment of the lung will be minimal. In contrast to this uranium found in nature, DU particles are pure, metallic uranium and for the most part insoluble. While immobilized within the lung, each DU particle will repeatedly bombard surrounding cells and impart to its target region a significantly greater quantity of radiation than would ever be imparted by particles of the uranium found in nature. The specific activity of ore with a concentration of 0.20 percent uranium is 4 nanocuries per gram. In contrast to this, the specific activity of depleted uranium metal is about 400 nanocuries per gram (Makhijani and Smith). Thus, particles of DU are on the order of 100 times *more* radioactive than the dust particles encountered by uranium miners.

Within the nuclear industry, there is a subpopulation of workers who do receive exposure to uranium in forms that emit levels of radioactivity greater than that emitted by DU. For instance, uranium mill workers are exposed to a concentrated form of natural uranium, yellowcake, which is 70 to 90 percent U_3O_8. Occupational exposure to forms of uranium more radioactive than DU can also potentially occur to workers involved in the conversion of natural uranium to uranium hexafluoride, uranium enrichment, the fabrication of uranium fuel and the assembly of reactor fuel rods, the fabrication and assembly of components for nuclear weapons and so forth. Potentially, studies of the health of these workers could provide relevant information of the chemical and radiological toxicology of uranium that would be pertinent to evaluating the hazard posed by depleted uranium. However, the extant epidemiological studies on nuclear workers working with uranium failed to collect the necessary data that would be required to accurately evaluate uranium's toxicity. Part One of the Royal Society's report cites 14 studies of workers in the nuclear industry, which when combined, involved a population of 120,000 people. Collating the data from these studies, the authors writing for the Royal Society concluded that this population exhibited no excess mortality from any of 13 cancers, all cancers combined or genitourinary disease. However, when the type of data on which these conclusions were based is examined, it becomes obvious that these studies are without value in deriving conclusions about the toxicology of internalized uranium. Many of the studies calculated total cancer mortality at various facilities without identifying which workers within these facilities actually had internal exposure to uranium. Six of the studies, involving nearly 25 percent of the total population under investigation, provided no information on exposure. Another

five studies, comprising nearly three-fourths of the combined study population, relied primarily upon measurements of *external* exposure. Some consideration was given to subgroups of workers receiving internal exposure in the mathematical calculations of cancer mortality, but no precise data on internal dosages to individual workers was available. The Royal Society was not oblivious to these limitations. It mentions that those workers who were actually exposed to internalized uranium were not identified and their level of internal exposure was never calculated.

> In general the largest exposures to uranium occurred during the 1940s and 1950s. At that time safety requirements were less stringent than now, record-keeping was limited, and very few individuals were tested for possible exposure to uranium or other radionuclides (individuals were generally tested for contamination only if there was an 'incident' such as a fire, large spillage, etc.). Therefore, there are few reliable measurements of exposure to uranium at the time when it was relatively high. Studies restricted to workers with measured internal exposure to uranium are thus often studies of recent workers, who had relatively low exposures. Also, a relatively small proportion of a total workforce would have been heavily exposed to uranium. Many people who work in uranium processing plants or similar places do not actually handle uranium themselves — for example security officers, builders, administrators, clerical workers and cooks would have minimal exposure. Thus the mortality experience of workers who actually handled uranium may be diluted by the experience of people with little or no direct exposure.

Studies that find depleted uranium to be without hazard often claim that epidemiological studies of workers in the uranium industry substantiate this claim. This is yet another scam. The data are not there to support this conclusion. Outside of a handful of accidents involving high levels of exposure to natural and enriched uranium, we are left with insufficient information regarding internal uranium exposure by nuclear workers to infer that DU exposure is without hazard.

Inhalation is the primary route of entry of battlefield uranium into the human body. Only brief mention need be given to the other routes of exposure. Nearly all of the uranium that is swallowed passes through the gastrointestinal tract and is eliminated in the feces. For purposes of modeling the kinetics of ingested uranium, the ICRP posits that 2.0 percent of soluble uranium compounds and 0.2 percent of insoluble compounds are absorbed into the circulation (ICRP 1995). This material then behaves identically to that which gains access to the body's interior through the alveoli. Somewhere between 67 and 90 percent is

rapidly excreted in the urine while the rest is distributed to the tissues of retention. It is important to note that animal studies suggest that fasting animals and animals suffering from malnutrition absorb substantially greater amounts of uranium from the gastrointestinal tract than normal. The same is true for newborn infants. Neonatal rats absorbed uranium in amounts of two orders of magnitude greater than that of adults (ICRP 1995). These facts may have important toxicological consequences to undernourished civilians caught in war zones or those taking up residence subsequent to battle where DU munitions have contaminated agricultural lands and water sources.

The skin has been investigated as a possible avenue of internal exposure. Animal studies have confirmed that for certain highly soluble compounds of uranium, dermal exposure can cause severe poisoning and death (Durakovic 1999). However, for the Type M and Type S compounds of uranium likely to be encountered on the battlefield, dermal exposure does not present a toxic risk. Concern, however, is warranted for possible absorption of DU through breaks in the skin and open wounds. Studies of animals have also investigated absorption of a variety of uranium compounds through the conjunctival sac of the eye. Different species manifested different sensitivities, and sensitivity was dependent on the type of uranium compound involved. In some animals, local damage was observed ranging from conjunctivitis to ulcerations of the cornea. Compounds of uranyl nitrate, fluoride and sodium-diuranate were absorbed from the conjunctiva and caused systemic poisoning (Durakovic 1999). The compounds of uranium likely to be found upon the battlefield, however, have not been shown to gain entrance into the circulation via this ocular route.

A small number of soldiers were exposed to battlefield uranium as a result of being wounded in friendly-fire incidents. Some retain shrapnel within their tissues. These fragments of uranium metal lodged within the body serve as a source for chronic systemic contamination which poses both a long-term chemical and radiological hazard. Monitoring the health of these veterans has become important for the Department of Defense in their mission to prove that depleted uranium is biologically benign. A detailed examination of the political significance of this cohort of victims will be provided later in the chapter.

The scholarly tomes that find DU inoffensive appear to present a reasonable argument that exposure to DU is no different than exposure to natural uranium and that past studies of uranium exposure can provide all the evidence that is required to prove that exposure to DU does not make people ill. In confirmation of this conclusion, we have seen that the compounds of uranium released upon the battlefield are considered physically and chemically identical to those encountered by uranium miners and workers in the nuclear industry. Although we have noted minor differences in particle size and solubility between

battlefield DU and uranium as it is encountered by those who receive ongoing occupational exposure, these differences appear inconsequential. Once uranium is dissolved and enters the circulation, it behaves the same whether it got there from exposure to natural uranium or exposure to depleted uranium. If natural uranium in doses likely to be received on the battlefield is nontoxic, depleted uranium must also be similarly innocuous.

The logic of the argument seems infallible. So where is the con?

The defenders of depleted uranium weaponry have written storybooks which fail abysmally in addressing the real-world effects of these weapons. These armchair researchers, starting from the observation that DU penetrators are close to 98 percent uranium-238, retreat to their textbooks to calculate the potential health implications of inhaled DU. Imagining that some portion of a penetrator is ground up into micron-sized bits and some portion of that is inhaled, they create models for the biological consequences. They estimate the relative percentage of the various oxides of uranium contained within each particle, the residency time of particles within the lung, their rate of absorption, their rate of elimination, the quantity of uranium deposited in each target organ, the dose of radioactivity to each exposed tissue and so forth. With their dose estimates in hand, they compare their calculations to previous studies of the toxicology of natural uranium. They then publish spurious conclusions as to what the likely consequences will be from internal exposure to depleted uranium. Suspiciously, all these studies fail to address the most significant aspect of DU munitions: ***the impact event***. When a uranium penetrator slams into its target, unique conditions are created which transform uranium, both physically and chemically, into forms so different from that of natural uranium found in mining and industry, that any attempt to liken the toxicology of the two is absurd. In addition, the high heat of uranium combustion sets all the materials contained within the target ablaze, producing a toxic cloud of metal alloys and chemical compounds whose toxicological effects cannot possibly be comprehended by dredging up timeworn studies on classical types of uranium exposure.

The depleted uranium used by the army is a little less than 98 percent pure uranium. Of this, 99.797% is uranium-238, 0.202% is uranium-235, and 0.0008% is uranium-234. The uranium is alloyed with 0.5% titanium, 0.75% molybdenum, 0.75% zirconium and 0.75% niobium. Due to the radioactive decay of uranium, thorium-234, protactinium-234m and protactinium-234 are also present in infinitesimally small quantities. Further, as a result of the introduction of spent nuclear fuel into the enrichment cascade of the Paducah gaseous diffusion facility, the US stockpile of depleted uranium is contaminated by trace quantities of uranium-236 plus the transuranic elements plutonium-239, americium-241, neptunium-237 and the fission product technetium-99. This is only the begin-

ning of the chemical and radiological nightmare that is depleted uranium.

While traversing the air on its way to the target, a DU penetrator is set ablaze by air friction. Upon impact, this burning is intensified. Between the heat of combustion and the friction of the dense uranium metal slicing through an armored vehicle, temperatures ranging between 3000^{O} and 6000^{O} C are created. This inferno vaporizes all materials in its vicinity. Metals, rubbers, plastics, fabrics and glass from the destroyed vehicle plus diesel fuel and organic matter from incinerated victims are sublimated. Minute particles from all these materials mix together in the super-hot cloud and commingle with the aerosolized uranium particles. For a brief period of time, conditions are perfect for the aerosols within the fume to recombine into novel metal alloys and other potentially toxic chemical compounds. As cooling and condensation begins, the molecular structure of the metal particles is reconfigured, transforming the particles into a crystalline-structured ceramic, spherical in shape and highly insoluble (Gatti and Montanari). The end-product of the conflagration is a witch's brew of uranium- and nonuranium-bearing particles possessing a complex chemistry. A preliminary study of the elements in the dust produced by the impact of DU munitions with an armored target revealed the presence of significant quantities of uranium, iron, aluminum and silicon plus trace quantities of silver, boron, barium, cadmium, cobalt, chromium, copper, magnesium, manganese, molybdenum, nickel, lead, strontium, titanium, zinc and zirconium (Mitchel and Sunder). In addition, complex spherical porous particles containing aluminum, potassium and silicon may be formed by DU munitions impacting with soil and alloying with clay and sand, or when hot, reactive, secondary particles from the initial impact interact with the soil environment (WHO, CHPPM). Because of the likelihood that novel uranium compounds are created from this complex chemical inventory of their targets, it is premature to declare that inhaled DU is harmless. Previous study of common uranium compounds has produced the cautionary discovery that each exhibits its own toxicological profile. Needless to say, the full spectrum of chemicals created by the impact event has yet to be scientifically analyzed. Neither the biokinetics or toxicology of this concoction of particles is known. On the subject of the hazardousness of depleted uranium, this is *terra incognita*.

One cannot brush aside this phenomenon when discussing the hazards posed by depleted uranium. In combat, DU rounds serve as catalysts for producing, on the spot, a wide range of chemical toxins. Both combatants and noncombatants in the vicinity are exposed to these poisons via inhalation, ingestion and absorption. Seen in this light, DU munitions are nothing less than the delivery vehicle for chemical agents into the air encompassing the battlefield. The matériel of military forces, exposed to pyrophoric DU, are transformed into unique and largely unexplored radioactive and chemical hazards. The synergistic effects among these various chemicals once inside the body, coupled with DU's

radiological effects, are an entirely new field of inquiry that is not receiving the attention it deserves. To say that human exposure to natural or enriched uranium will provide an explanation of the medical effects from DU's activity on the battlefield is nothing less than preposterous.

The pyrophoric nature of uranium is responsible for an additional phenomenon which, not surprisingly, has received scant attention by the peddlers of politicized science. The combustion of uranium munitions and their targets releases into the atmosphere ultra-fine particles. Those with a diameter measuring less that 100 nanometers are referred to as "nanoparticles." (A nanometer is one-billionth of a meter. One hundred nanometers is equivalent to 0.1 micron.) Microscopic specks of this dimension have become the subject of intense scientific investigation due to the fact that they are the centerpiece of the emerging discipline of nanotechnology. For those unfamiliar with this modern marvel of engineering, nanotechnology is "the manipulation, precision placement, measurement, modeling, or manufacture of sub-100 nanometer scale matter" (Meyer *et.al*). As defined by the National Nanotechnology Initiative, nanotechnology is "research and technology development at the atomic, molecular or macromolecular scale, leading to the controlled creation and use of structures, devices and systems with a length scale of 1-100 nanometers (nm)" (Gwinn and Vallyathan). Proponents of nanotechnology are declaring it to be the greatest innovation in engineering since the Industrial Revolution. Armed with the ability to manipulate the physical, chemical and biological properties of molecular-sized structures, humans can now fabricate novel materials with enhanced strength, durability, flexibility and performance. Medical researchers are on the threshold of creating designer molecules for innovations in medical imaging, disease diagnosis, drug delivery, cancer treatment and gene therapy. Manmade catalysts and microscopic machines are in development that will create new manufacturing processes and lead to a host of innovative consumer products. One obstacle to the realization of this utopian vision is the possibility that exposure to nano-sized particles may be toxic to humans. This concern has spawned the discipline of nanotoxicology.

Nanoparticles are not a new phenomenon. What is new is the increasing attention they are receiving from biologists and epidemiologists. Nanoparticles are routinely produced during a number of different types of combustion. For instance, the combustion of gasoline and diesel fuel in automobile engines releases single particles as small as five to 20 nanometers and aggregates of particles ranging in size from 60 to 100 nanometers and larger (Donaldson *et al.,* 2005). Both epidemiological and animal studies have demonstrated that inhalation of these particles can produce oxidative stress and inflammation and that they are carcinogenic. The underlying mechanism responsible for these can be summarized as follows:

> The combustion materials and the mode of combustion will ultimately determine the characteristics of the CDNP [combustion-derived nanoparticles], including chemical composition, particle size and particle solubility. The large surface area of CDNP presents maximal opportunity for dissolution of soluble species from the surface of the insoluble core. For insoluble NP, the large surface area provides a surface on which catalytic chemistry can occur that favors the formation of free radicals. These free radicals are responsible for driving oxidative stress, the underlying mechanism that promotes an inflammatory response to CDNP (Donaldson *et al.*, 2005).

An excellent summary of oxidative stress is offered by Klein and Ackerman in their article *Oxidative Stress, Cell Cycle and Neurodegeneration*:

> Under normal physiological conditions, it is estimated that up to 1 % of the mitochondrial electron flow leads to the formation of superoxide ($O_2.\_$), the primary oxygen free radical produced by mitochondria; and interference with electron transport can dramatically increase $O_2.\_$ production. While these partially reduced oxygen species can attack iron sulfur centers in a variety of enzymes, $O_2.\_$ is rapidly converted within the cell to hydrogen peroxide (H_2O_2) by the superoxide dismutases (SOD1, SOD2, and SOD3). However, H_2O_2 can react with reduced transition metals, via the Fenton reaction, to produce the highly reactive hydroxyl radical (.OH), a far more damaging molecule to the cell. In addition to forming H_2O_2, $O_2.\_$ radicals can rapidly react with nitric oxide (NO) to generate cytotoxic peroxynitrite anions ($ONOO^-$). Peroxynitrite can react with carbon dioxide, leading to protein damage via the formation of nitrotyrosine and lipid oxidation.
>
> The generation of ROS [reactive oxygen species] in normal cells, including neurons, is under tight homeostatic control. To help detoxify ROS, biological antioxidants, including glutathione, alpha-tocopherol (vitamin E), carotenoids, and ascorbic acid, will react with most oxidants. In addition, the antioxidant enzymes catalase and glutathione peroxidase detoxify H_2O_2 by converting it to O_2 and H_2O. However, when ROS levels exceed the antioxidant capacity of a cell, a deleterious condition known as oxidative stress occurs. Unchecked, excessive ROS can lead to destruction of cellular components including lipids, protein, and DNA, and ultimately cell death via apoptosis and necrosis.

Pertinent to the subject of aerosolized DU on the battlefield is the experience of

welders. Welders routinely inhale nano-sized particles of aluminum, cadmium, chromium and copper. The body's response to these pollutants is worthy of note:

> Exposure to welding fume has been associated with both pulmonary and systemic health endpoints. These include decreases in pulmonary function, increased airway responsiveness, bronchitis, fibrosis, lung cancer and increased incidence of respiratory infection; in addition to these pulmonary effects, metal fume fever is frequently observed in welders. This systemic condition is considered to be caused by inhalation of zinc oxide fumes and it is characterized by acute onset of a flu-like illness accompanied by a dry cough, dyspnea, muscle aches, headaches and fever. Metal fume fever is usually experienced in the first periods of exposure and on Mondays, with the symptoms declining as the working week progresses. Welding fume has been studied in both animals and in cells in culture, and in both it produces marked proinflammatory effects. These effects are driven largely by the transition metals which undergo redox-cycling resulting in oxidative stress (Donaldson *et al*).

When it is recognized that combustion routinely produces nano-sized particles, the question naturally arises as to whether or not this phenomenon is relevant to burning uranium penetrators and the fires that consume destroyed armored vehicles. As reported earlier, the study of Glissmeyer and colleagues found that nearly a third of the particles generated by DU munitions colliding with armored targets measured less than 0.18 microns. Of greater significance is the observations by Antonietta Gatti[1] and Stephano Montanari who found combustion-derived nanoparticles in the tissues of people suffering from Balkan War Syndrome. In their article "The So-Called 'Balkan-Syndrome': A Bio-Engineering Approach," they describe how soldiers serving in the former Yugoslavia during the Balkan War, staffers of humanitarian missions and Yugoslavian residents are suffering from some unknown illness similar to that suffered by US soldiers who served in the Gulf. The link that existed between these two theaters of war remained a mystery until March 2000, when NATO announced that DU munitions had been fired in the Balkans. The United Nations Environment Protection agency confirmed this report the following year when field teams

[1] Stefano Montanari, a pharmacist and scientific consultant, has provided in a preface to his article "A Bioengineering Approach to the Disease Induced by DU" (http://www.health-now.org/site/article.php?articleId=154&menuId=17) these credentials for his colleague: "Antonietta Morena Gatti is a physicist and bioengineer, and is the founder and the director of the Laboratory of Biomaterials of the University of Modena and Reggio Emilia (Italy). She is the discoverer of the presence of micro- and nano-particles in biological tissues and of their pathological effects. The European Community appointed her Coordinator of the international group in charge of the nanopathology study."

discovered traces of radioactivity not far from Sarajevo. In coming to suspect that DU exposure linked so-called Balkan War Syndrome to Gulf War Syndrome, Gatti and Montanari examined the many other hypothesized instigators of the disease suffered by those who served in Operation Desert Storm. They discounted each of these in turn because these were not shared by those serving or residing in the Balkans. Balkan residents did not receive vaccines against tetanus-diphtheria, hepatitis B, poliovirus, meningococcal, typhoid and yellow fever. Unlike American troops, they were not treated with Botulinum Pentavalent to counter botulism. They did not receive a vaccination against anthrax. And they were not treated with Pyridostigmine Bromide, a pre-treatment against nerve gas agents. The only apparent link between those sickened individuals in the Balkans and ill individuals in the Gulf was exposure to depleted uranium and its combustion products.

Using an innovative technique of electronic microscopy, Gatti analyzed tissue samples taken from victims of Balkan War Syndrome. Every sample that was tested contained inorganic microparticles and nanoparticles. According to Gatti and Montanari:

> We have amply demonstrated with our researches that once debris that size ($10^{-9} - 10^{-5}$ m) enter the body, be it via the digestive or the respiratory system, they can easily negotiate the luminal tissues and either be captured by the tissue itself which acts the way a filter does, or be transported by the blood or the lymph until they end their travel in some organ (for instance the kidneys and the liver). Lymph nodes, for example, are the organs where lymphomas start and develop and where, in all pathological cases checked, we found the presence of inorganic particles. But also all the other pathologic specimens we had the possibility to observe show clearly and without any single exception the presence of debris.

Many of the particles observed by Gatti were spherical in shape and hollow in the larger sizes, confirming that they were formed under very high temperatures. According to the authors, when the particles were analyzed, what was found were "small bits, sometimes agglomerated, of simple and combined metals." These included particles of iron-silicon, copper-chlorine-zinc, silicon-titanium-iron-aluminum, silicon-bismuth, silicon-lead, iron-copper-zinc, chromium-iron-nickel, iron-manganese, and one particle of pure zirconium. To confirm an environmental origin, the authors noted that particles found in tissues of diseased soldiers and civilians were "mutually compatible" with those found on the ground in the territories where the pathologies were contracted. The authors found it curious that no evidence of uranium was discovered in any of their samples. Their explanation of this is not unreasonable:

> If no uranium was ever detected, that does not necessarily mean there is none somewhere in the tissues of the patients. The fact is likely to be due to its quantity, which is extremely scarce when compared with the huge masses of the targets that sublime and that contain no such element. It is also possible that uranium particles had been captured by tissues but, probably because they did not reach a critical threshold, did not trigger any disease and, as a consequence, we did not have the chance to receive and study the samples.

The importance of this preliminary research by Gatti and Montanari cannot be overemphasized. It proves that combustion-derived, metal-alloyed nanoparticles are present in the tissues of those suffering from a previously undiagnosable illness. Follow-up study is urgently needed. An obvious study group would be ill veterans who have tested positive for the presence of depleted uranium in their urine and who have been excreting DU continuously for a number of years. Confirmation that these individuals carry combustion-derived nanoparticles in their tissues would open a valuable avenue of research into Gulf War Syndrome.

It is not possible to make generalizations about the behavior of nanoparticles once inside the body. Variation in size by just a few tens of nanometers and in chemical composition will produce marked differences among species of particles in their biokinetic properties and biological effects. However, to introduce the reader to the new world of nanopathology, some of the unique characteristics of nanoparticles can be introduced to illustrate how these might be toxic to the contaminated organism. Describing the biokinetics of nanoparticles, Oberdörster and colleagues summarize their behavior as follows:

> The biologic activity and biokinetics are dependent on many parameters: size, shape, chemistry, crystallinity, surface properties (area, porosity, charge, surface modifications, weathering of coating), agglomeration state, biopersistence, and dose. These parameters are likely to modify responses and cell interactions, such as a greater inflammatory potential than larger particles per given mass, translocation across epithelia from portal of entry to other organs, translocation along axons and dendrites of neurons, induction of oxidative stress, pro-oxidant and antioxidant activity of NSPs in environmentally relevant species, binding to proteins and receptors, and localization in mitochondria (Oberdörster *et al.* 2005).

Quite obviously, the single most important property of nanoparticles is their small size. Their unique dimensionality permits them to migrate throughout living systems in

novel ways. For instance, while in an insoluble form, nanoparticles can freely translocate across the alveolar epithelium. A Belgian research group confirmed this phenomenon when observing that *insoluble* 100 nm particles freely crossed the alveolar barrier and entered the blood within one minute of inhalation. Within an hour, this material was found in the liver (Fontanova). In addition, nanoparticles have been observed migrating from the lung by crossing the pulmonary epithelium. This translocation through tissue that is impermeable to larger-sized particles allows ready access to an organism's internal environment. In "Nanotoxicology: An Emerging Disciple Evolving for Studies of Ultrafine Particles", Oberdörster and associates (2005) make the following observations:

> Once deposited, NSPs [Nanosized Particles] — in contrast to larger-sized particles — appear to translocate readily to extrapulmonary sites and reach other target organs by different transfer routes and mechanisms. One involves transcytosis across epithelia of the respiratory tract into the interstitium and access to the blood circulation directly or via lymphatics, resulting in distribution throughout the body. The other is a not generally recognized mechanism that appears to be distinct for NSPs and that involves their uptake by sensory nerve endings embedded in airway epithelia, followed by axonal translocation to ganglionic and CNS structures.
>
> The biokinetics of NSPs are different from larger particles. When inhaled, they are efficiently deposited in all regions of the respiratory tract; they evade specific defense mechanisms; and they can translocate out of the respiratory tract via different pathways and mechanisms (endocytosis and transcytosis). When in contact with skin, there is evidence of penetration to the dermis followed by translocation via lymph to regional lymph nodes. A possible uptake into sensory nerves needs to be investigated. When ingested, systemic uptake via lymph into the organism can occur, but most are excreted via feces. When in blood circulation, they can distribute throughout the organism, and they are taken up into liver, spleen, bone marrow, heart, and other organs. In general, translocation rates are largely unknown; they are probably very low but are likely to change in a compromised/diseased state.

There are a number of interesting facts about the biokinetics of nanosized particles that deserve emphasis. First of all, their small size enables them to avoid rapid filtration from the blood in both the spleen and the liver. As a consequence, nanoparticles have ready access to all areas of the body. They may even circulate continuously, engaging in repeated molecular interactions and gradually releasing surface molecules throughout the system

while slowly dissolving. Thus, insoluble uranium nanoparticles represent a source for chronic chemical and radiological poisoning in the body's interior. Second, it has been demonstrated that under some conditions nanoparticles are able to avoid detection by macrophages. This invisibility to the immune system results from the failure of nanoparticles to set off the chemical signaling mechanisms that alert and guide macrophages to invaders. This has important ramifications in the lung due to the fact that phagocytosis of solid particles by alveolar macrophages is the most important clearance mechanism of minute debris. Their prolonged residency in the lung grants nanoparticles a window of opportunity for translocation across the epithelium to interstitial sites. Third, nanoparticles may promote autoimmune disorders. As mentioned by Donaldson *et al.* 2004: "Very small particles are smaller than some molecules and could act like haptens to modify protein structures, either altering their function or rendering them antigenic, raising the potential for autoimmune effects." Fourth, nano-sized particles are capable of migrating along the axons of nerve cells. In both the nasal and tracheobronchial regions, some varieties of nanoparticles have been observed passing into nerve cells through nerve endings of the olfactory and trigeminus nerves and the sensory nerves endings in the tracheobronchial region (Oberdörster *et al.*). Inhaled nanoparticles can cross the nasal olfactory mucosa and cross into the olfactory bulb. From there they can translocate along nerve fibers. This access to the central nervous system is one route by which nanoparticles can enter the brain. Referencing the article "The Olfactory Neuron and the Blood-Brain Barrier" by A.J. de Lorenzo, Oberdörster *et al.* make this important observation: "NSPs in the olfactory bulb were no longer freely distributed in the cytoplasm but were preferentially located in mitochondria."

Nano-sized particles exhibit one further biokinetic property that has important implications for DU exposure. Nanoparticles are capable of entering the organism through the skin. Particles ranging in size from 0.5-7.0 microns can freely enter the body through breaks in the skin. This has been confirmed in studies in the tropics of people suffering from elephantiatic lymphedema. Study subjects who routinely walked and ran barefoot were found to have accumulated large amounts of soil particles in their inguinal lymph nodes (Corachan *et al.*, Blundell *et al.*). Perhaps more importantly, nanoparticles can translocate across unbroken, flexed skin or areas of slim folds in the skin (but not flat skin). As mentioned by Oberdörster *et al.*, Tinkle and colleagues demonstrated that fluorescent beads one micron in size can pass through flexed areas of the epidermis. The elephantiasis studies referred to above confirm that this material can subsequently be taken up by the lymphatic system and deposited in regional lymph nodes. Transfer of nanoparticles from lymph nodes to the blood has been demonstrated to occur with small asbestos fibers (Oberdörster *et al.* 1988). These routes suggest that nanoparticles entering through the skin have access to the circulatory system. The ability of nanoparticles to gain entrance to the

body through the skin may have importance for depleted uranium exposure. A number of veterans of the Gulf War reported developing symptoms of illness after working around contaminated equipment or entering destroyed enemy tanks.

In addition to their small size, a second characteristic of fundamental importance to the toxicology of nanoparticles is their increased surface area relative to their mass when compared to larger particles of equal mass. By way of example, a square chunk of DU, 20 microns on a side, will have a significantly smaller surface area than that same chunk ground up into spherical nanoparticles of 100 nm in diameter. To state it simply, "the ratio of surface to total atoms or molecules increases exponentially with decreasing particle size" (Donaldson *et al.* 2004). Greater surface area translates into greater reactivity. Greater reactivity translates into greater biological effect. The biochemical and physiological behavior of nanoparticles, and the accumulated effects on an organism of large numbers of particles, is thus largely determined by the surface chemistry of the particles. The atomic configuration of molecules covering the surface of nanoparticles dictates the types of chemical interactions they will enter into in a biological system and the types of reactions they may catalyze. The surface chemistry of nanoparticles is responsible for the inflammation and oxidative stress routinely observed in contaminated organisms. To put nanoparticles into proper perspective, it is important to note that the typical cell in the human body is between 10,000 to 20,000 nm in diameter. Thus, these particles are on a scale where their surface chemistry can interact with the surface chemistry of individual cells. Cell membranes are permeable to some species of nanoparticles. This allows them to take up residence within the cytoplasm or the organelles within cells. Being of the size of biological macromolecules such as enzymes or receptors, their presence can influence cell function. At this point, it is interesting to note that the release of transition metals from the surface of nanoparticles has been implicated in gene activation.

One fact that cannot escape mention is that alpha-emitting nanoparticles pose an increased radiation hazard over larger-sized particles. This is due to the fact that as particle mass increases, the chance of an alpha particle escaping to interact with the surrounding medium decreases. In larger-sized particles, alpha radiation is absorbed within the particle itself, either by being emitted inward toward the particle's center or by being absorbed by the more surface atoms. Only alpha particles emitted by atoms relatively near to a particle's surface have the chance of escaping to wreak havoc outside the particle's mass. To quote Dan Bishop of International Depleted Uranium Study Team (IDUST):

> Only alpha radiation from those atoms on or near the surface of the particle has any chance of escaping outside the particle and causing damage. For this reason, it is apparent that the smaller particles with

> larger surface area are significantly more hazardous than the larger particles in natural uranium dust.

In accordance with this observation, Rosalie Bertell draws attention to the fact that nanoparticles are the perfect vehicle for delivering the maximum chemical and radiological dose to the interior of the human body:

> In an internal aerosolized ceramic form, the maximum possible dose from the radioactive chemicals is delivered to the victim, and the maximum toxic metal effect can be caused. This is because in a pulverized ceramic form, of nanometer size, the surface area is maximized, the self-shielding is minimized, and the solubility in body fluid is minimized, resulting in a maximum contact dose (Bertell, September 2005).

The physiological conditions that allow this enhanced toxicity of uranium nanoparticles to operate is concisely summarized by Bertell:

> The 19 to 38 nanograms of natural uranium that is absorbed through the intestinal wall is considered to be internal to the body. It passes through the hepatic portal system and is screened by the liver, then either sent directly to the kidneys to be excreted in urine or circulated in the blood. Circulating uranium is usually stored in bone, to be excreted at a later time. These outcomes vary according to the solubility of the uranium compounds in food and water. However, these estimates are typical for natural uranium. The human body has an excellent screening system for natural uranium reducing the ambient average environmental concentration of 1 part per million to less than 38 parts per billion internally. However, this gastrointestinal and liver screening system does not operate to screen out the uranium or other metals that enter the body through the lungs, are ceramic, and have an aerodynamic diameter in the nanometer range. Gulf War exposures to inhaled DU were likely well above the normal 19 to 38 nanograms per day and added considerable stress to the body, regardless of the other stresses present in this toxic war. Nano-particles (whether uranium, steel, iron, or aluminum) pose an especially difficult problem for the body's screening and filtering ability. They pass through the lung-blood barrier, the blood-brain barrier, and the placenta, and they are too small to be filtered out by the kidneys and excreted from the body (Oberdörster et al. 2005). They take a long time to dissolve in the body fluid, and only the dissolved portion can be chemically active or eliminated in urine. Because of the variable

> times needed for dissolving the ceramic forms, the negative effect of the radioactive heavy metal is ongoing. Ceramic uranium may never dissolve, and it does not lose its radioactive properties (Bertell 2006).

When the United States was forced to admit that its DU munitions were contaminated with transuranics, research was hurriedly released reassuring the world that these contaminants did not significantly increase the radioactivity emitted by DU. However, little attention was given to the possible chemical toxicity of these contaminants. Atoms of americium, neptunium and plutonium may be embedded on the surface of depleted uranium nanoparticles. These could very well be chemically toxic in ways that have yet to be identified. Clearly, the toxicity of depleted uranium cannot possibly be determined by an isolated study of the toxicology of uranium alone. When DU munitions destroy an armored target, combustion-derived nanoparticles with complex surface chemistries are created. Their behavior upon entering the human body and their possible negative consequence have yet to be investigated. To claim that ill individuals exposed to depleted uranium have not become ill because of this exposure is a premature conclusion with no scientific validity. In a moment of candor, the Royal Society's study of depleted uranium includes this confession:

> The variability and uncertainties in the absorption rates of inhaled uranium oxides released in DU penetrator impacts or fires necessitate caution during the calculation and interpretation of uranium biokinetic data. For example, there is very limited information regarding the solubility and toxicity of Ultrafine particles of DU. The behavior in the body of uranium that is ingested is well understood. There are more uncertainties associated with the behavior of inhaled uranium particles in humans, and in the absence of specific data on the solubility and bioavailability of the DU oxides (including the microfine component), extrapolation from the behavior of uranium in animal models may not always be valid. More data are required on the dissolution and absorption characteristics of DU in the aerosols formed as a consequence of the combustion and thermal oxidation of DU that occur on the battlefield, and whether the inhalation toxicity of these materials in animals is different from that of other uranium oxides that have been studied.

Sobering, too, is this observation:

> There are no data on the long-term effects of the use of DU munitions on humans and the environment because they were first used in a military conflict in 1991 during the Persian Gulf War.

> Consequently the long-term risks to health and the environment have been evaluated in the absence of data over appropriate time-scales (Royal Society).

The ground so far covered by this chapter can be mapped as follows. When depleted uranium munitions destroy their target, a complex assortment of particles are vented into the air. A portion of these will be small enough to be inhaled or swallowed. Of these, some fraction will consist of medium- and slow-dissolving particles of pure uranium with diameters in the micrometer range. Once in the lung or in the gut, these particles will behave in the manner outlined by the scientific studies of the Royal Society, the World Health Organization and so forth. Their conclusion that DU will produce no adverse health effects remains arguable only as long as the other particles created by DU impacting on targets are omitted from consideration. But such omission is reprehensible and irresponsible. DU-produced fires create other species of particles that will also be a hazard to health. Pure uranium nanoparticles will be produced that, once inside the body, will have different behavioral characteristics than the larger micrometer-sized particles. In addition, uranium alloys and nonuranium-bearing alloys of both micrometer and nanometer dimensions will be produced. The synergistic effects of all of this debris once inside the body; the radiological effects of DU, its transuranic contaminants and their decay products; and the synergy between the chemical and radiological effects all combine to create hazards which remain undefined.

Let's stop kidding ourselves. The penned defenses of depleted uranium are unscientific twaddle, hokum elevated to a fine art. They are intentionally obstructionist, written to cloud understanding of DU's physiological effects rather than to clarify them. They trivialize the complex phenomenon of depleted uranium aerosols created on the battlefield, fabricating a totally inappropriate comparison to exposure to the uranium found in nature and in industry. The created toxicity is then dismissed by an outdated and irrelevant review of research on uranium workers. The Royal Society concedes that this approach may lead to totally irrelevant conclusions. Buried in the midst of their long-winded exercise in distraction, they fess up with the following admission: **"the typical forms of the inhaled particles in industrial settings and on the battlefield will be different, and these alternative forms might not have the same adverse effects."**

Having breached the hollow defenses erected to safeguard depleted uranium's use on future battlefields, the task remaining is to examine the scientific literature as it pertains to uranium's toxicity. What needs to be aired in the light of day are the endpoints of concern from uranium exposure other than kidney disease and cancer. This investigation will occupy the remainder of this chapter. Before proceeding, however, the reader will harvest tremendous intellectual bounty from a brief review of an article deserving widespread

recognition. In 2006, the *International Journal of Health Services* published a paper by Rosalie Bertell entitled "Depleted Uranium: All The Questions About DU and Gulf War Syndrome Are Not Yet Answered." Bertell's cogent writing forcefully argues the need for a paradigm shift when attempting to understand such a complex phenomenon as Gulf War disease. Rather than continuing to search for a single underlying cause of this illness, Bertell provides a preliminary outline for a "holistic" and "interactive" model of the "toxic matrix" of exposures suffered by those made ill in the theater of battle.

Bertell begins her discussion with an inventory of the numerous toxins present in Iraq to which both army personnel and civilians were exposed. Briefly, she outlines that in addition to DU exposure, there were numerous opportunities for exposure to other heavy metals including mercury, lead, arsenic and cadmium. These were present in pesticides, herbicides, vaccines, nerve agents, and releases into the environment from destroyed Iraqi military and industrial installations. Added to this was exposure to petroleum products and the blanketing smoke from the oil well fires.

Given that multiple exposures were the rule rather than the exception, Bertell argues that looking for "**THE**" cause of Gulf War Illness is an ill-conceived endeavor which will ultimately prove fruitless. To even attempt such an approach is symptomatic of the reductionistic thinking that Bertell identifies as the major obstacle to achieving true and accurate understanding of the disease process. In her own words, Bertell states:

> One focus of the dispute about Gulf War syndrome (GWS) has been whether or not the use in battle of DU weaponry could be one of the principal causes of the disabling syndrome. The first roadblock to clarifying this scientific hypothesis results from focusing on only one item at a time to which veterans were exposed in battle and attempting to prove that it was or was not one of the main causes of their serious illness. One could attempt to do this for each pesticide, vaccine, toxic chemical, and heavy metal separately, pretending to prove for each that it was not the cause. Such reductionist discourse confuses the true issues and delays research into treatment and legal recognition of harm caused. It leads one to the absurd conclusion that the veterans are not really sick — that the problems are all in their imagination. Influential papers by physicists and several semiofficial governmental organizations have attempted to eliminate DU from consideration by just such analyses. These studies are not really independent, since each follows the guidelines, methodology and risk estimates recommended by the International Commission on Radiological Protection (ICRP).

When writing these words, Bertell must have been touched by enlightened prescience. In September 2006, the Institute of Medicine published a report commissioned by the US Department of Veterans Affairs that concluded there was no such thing as Gulf War Syndrome. Only reductionistic thinking could produce such a verdict. Hundreds of thousands of fit and healthy individuals went off to the Iraq theater to serve their country and returned home ill and debilitated. Although it appears to be a no-brainer that these are victims of service-related injury, by current diagnostic criteria, there's no provable association between exposure to the array of toxins mentioned and the diverse symptoms being suffered. The authors of the Institute of Medicine's study reported that they had found no cluster of symptoms to be unique to Gulf War veterans that could constitute a syndrome, and that no diagnostic markers had been identified that could be used to classify the veterans' illnesses as originating from a common cause. In other words, the authors concluded that Gulf War Syndrome is nonexistent. In reaching this conclusion, the study did not deny that Gulf War veterans "reported" significantly more symptoms of illness than veterans who had not been deployed in the Gulf. However, such reports could not be validated by so-called objective diagnostic testing or previously established associations between a given toxin and a particular illness or group of symptoms. It goes without saying that this conclusion will be a major obstacle to Gulf War veterans seeking compensation from the government for their illnesses. Upon the sick is laid the burden of proof that their illnesses are real and the result of military service. Shamefully, as with the atomic vets of the 1950s and the Vietnam veterans exposed to Agent Orange, the US government is sending our heroes to the trash bin. Why anyone would volunteer for military service so as later to be abused by the government they fought for is a mystery beyond comprehension.

The conclusions reached by the Institute of Medicine's study are flawed and obscure understanding of the debilitations that soldiers carried home from the Gulf. First, the authors do not consider the possibility that a syndrome may in fact exist but remains undiscovered due to inadequate research. Perhaps no syndrome has been discovered because current diagnostic criteria are limited or inappropriate for defining this new disease entity. Perhaps researchers are failing to look under certain rocks for fear of what might be found. For instance, without widespread testing of the ratio of uranium isotopes in the urine of ill veterans or analysis of combustion-derived nanoparticles in tissue samples, how can it be concluded that contamination with depleted uranium is not a common marker of Gulf War Illness? Second, why should members of a population exposed to a witch's brew of chemical and radiological toxins manifest the same physiological responses? By way of example, we have drawn attention to the fact that nanoparticles can freely circulate throughout the whole body and take up residence in a number of different organs. Under these circumstances, there is no reason to believe that their chemical and radiological properties would provoke a common physiological response. Third, little is known about the

synergistic effects of the various toxins to which Gulf War veterans were exposed. This vast field of ignorance calls into question any purported "scientific" verdict on the nonexistence of a syndrome. Fourth, depending on how one reads the Institute of Medicine study, one may easily conclude that the "self-reporting" of symptoms by veterans somehow demotes their illnesses to being unreal, feigned, or of psychological origin. Fifth, there is a political agenda hidden within the Institute of Medicine's study that must not be overlooked. By declaring that Gulf War syndrome does not exist, the study undermines future efforts to seek common causes for this non-disease. Conveniently, depleted uranium is once again given a clean bill of health. No syndrome, no problem. By accepting researchers' failure to thoroughly investigate DU contamination in veterans and then declaring that a syndrome is nonexistent, the medical establishment colludes with warriors of the Department of Defense, giving license for the continued fielding of toxic weapon systems.

Rosalie Bertell's campaign against reductionism continues with an astute criticism of the radiation effects model promulgated by the ICRP. According to Bertell, the ICRP model is grossly flawed for a number of reasons: (1) The model is overly reductionistic, confining radiation's health effects to damage to nuclear DNA and the fatal cancers that result. (2) The model is an idealization, based on an abstraction of what constitutes a standard human being. (3) The model is incapable of addressing the synergistic effects between exposure to radiation and other toxic substances. Bertell makes these observations:

> The widely accepted scientific causality methodology for analyzing radiation dose-response includes a mathematical model predicting damage to the cellular DNA resulting from a homogeneous spread of ionizing radiation over the critical organ(s), weighting the organ dose to approximate whole-body exposure, and using a risk formula to estimate the expected number of fatal cancers due to that dose. If the calculation yields only a small expected number of cancer deaths, the radiological hazard is declared to be trivial. This ICRP methodology assumes that the affected persons care only about cancer death, that they have normal physiological health and intact cellular repair systems, and that no other life-threatening exposures confound the radiation experience. The methodology assumes that radiation effects are independent of the effects of the toxic matrix and can be separately ruled out using a radiation-exposure-specific mathematical formula recommended by physicists on the main committee of the ICRP.
>
> Whether an assumption of homogeneous spread of the energy over the organ in question is reasonable under the circumstances, whether the estimates of the amount of radiation inhaled are accurate in the confusion of the battlefield, whether the cellular repair system is work-

ing, whether the clearance rate for heavy metals by the kidneys is normal, or even whether cancer is meaningful as the biological endpoint of concern for veterans — all makes no difference. These details seem to be irrelevant when applying this objective methodology. The mathematical equation contains no terms for dealing with cellular repair dysfunction, damage to mitochondrial DNA, and synergistic effects with a variety of toxic metals, halogens, and complex nano-debris.

In 1945, the physicist Erwin Schrödinger published what became one of the most influential monographs of the incipient atomic age. In *What Is Life* Schrödinger gave the central and primary informational role in life to the nuclear DNA. He found it to be the basis of all organic existence, and he explained it well in terms of fundamental physical and quantum principles. This was a brilliant thesis, and it was followed in 1953 by Watson and Crick's discovery of the method of DNA replication. DNA was spectacular news in the scientific world at this time. However, nuclear DNA, while central to protein production and human reproduction, failed to describe the many seemingly unrelated life-support mechanisms, including the tasks of mitochondrial DNA, which also go into making the cell functional. The developing science of radiobiology accepted the thesis that nuclear DNA was the essential molecule of radiosensitivity, and this focus continues to strongly influence decisions about the potential hazard of exposures to ionizing radiation, even in 2006, as nations are called upon to deal with the complex Gulf War syndrome. We now know that cellular organelles, cell membranes, and biochemical reactions within the cell are crucial when assessing the simultaneous damage caused by internal radiation, heavy metal contamination, and nano-particles. The radiation dose-response methodology, developed from studies of high-level radiation, seems to work by masking the low-dose effects. It is not appropriate for understanding low-dose DU exposures, because radiation, heavy metals, and other toxic chemicals can destroy the functionality of the cellular respiratory system (the mitochondria), disrupt the chemistry of enzymes and hormones, frustrate normal cellular detoxification and repair, and leave the person alive but chronically ill. Also at low doses, many other toxic agents become potentially synergistic or significant confounding variables for any radiation toxic effect.

The problems of Gulf War syndrome are too complex for a reductionist methodology that extracts the toxic effect of a single component,

> even depleted uranium. Increased free radicals, heavy metal toxicity, the complexity and sensitivity of disrupted cellular reactions, damaged organelles, dysfunctional enzymes and hormones, and mycoplasmal invasion — all occurring simultaneously within vital organs — pose monumental problems for function and survival. The mathematical methodology used by physicists is inappropriate for an insoluble nanoparticle such as the ceramic DU internally deposited along with this toxic soup. The standard mathematical calculation of the radiation risk of cancer death is likely misleading, because of the many other carcinogenic mechanisms, cellular repair dysfunction, and complex biochemical reactions not incorporated into the mathematics. For those veterans with illnesses resulting from internal radioactive contamination and multiple cellular dysfunction problems, who are trying to live normally and work to support their families, the radiation physics prediction of low radiation-related cancer death risk is likely both wrong and irrelevant. However, regulators will take the mathematical prediction very seriously when awarding compensation.

Bertell argues that in order to decipher the role played by depleted uranium in Gulf War disease, its effects must be studied within the context of the multiple exposures received by veterans from the total toxic matrix of the battlefield. As an example, Bertell junks the ICRP model of "cancer-as-the-only-endpoint-of-concern-from-radiation-exposure" and turns her attention to the potential adverse effects induced by oxidative stress. Individually, radiation, heavy metals and nanoparticles are known to induce oxidative stress. In the contaminated individual, chronic internal exposure to all three can produce free radicals in such quantities that they overwhelm the antioxidant defenses present in cells. Disarmed and unable to adequately protect themselves, cells become vulnerable to adverse structural and functional changes. Free radicals can damage DNA, degrade mitochondria and cell membranes, interfere with intra- and intercellular communication, and obstruct proper synthesis of proteins, enzymes and hormones. In addition, oxidative stress can provoke an inflammatory response. It is by this means that combustion-derived nanoparticles are thought to produce their deleterious effects (Donaldson 2005). Internal contaminants that produce chronic oxidative stress and a chronic inflammatory response may be responsible for autoimmune-like disorders. Oxidative stress has been implicated as a causative factor in a number of diseases. In the article "Oxidative Stress, DNA Damage and Human Diseases," the following inventory is provided:

> Oxidative stress has been thought to contribute to the general decline in cellular functions that are associated with many human diseases including Alzheimer disease, amyotrophic lateral sclerosis (ALS),

> Parkinson disease, atherosclerosis, ischemia/reperfusion neuronal injuries, degenerative disease of the human temporomandibular joint, cataract formation, macular degeneration, degenerative retinal damage, rheumatoid arthritis, multiple sclerosis, muscular dystrophy, human cancers as well as the aging process itself (Kow).

In "Free Radicals and Oxidative Stress in Neurodegenerative Diseases: Relevance of Dietary Antioxidants," Singh *et al.* compiled a more extensive list of free-radical-induced diseases:

> Damage due to free radicals caused by ROS leads to several damaging effects as they can attack lipids, protein/enzymes, carbohydrates, and DNA in cells and tissues. They induce undesirable oxidation, causing membrane damage, protein modification, DNA damage, and cell death induced by DNA fragmentation and lipid peroxidation. This oxidative damage/stress, associated with ROS is believed to be involved not only in the toxicity of xenobiotics but also in the pathophysiological role in aging of skin and several diseases like heart disease (atherosclerosis), cataract, cognitive dysfunction, cancer (neoplastic diseases), diabetic retinopathy, critical illness such as sepsis and adult/acute respiratory distress syndrome, shock, chronic inflammatory diseases of the gastrointestinal tract, organ dysfunction, disseminated intravascular coagulation, deep injuries, respiratory burst inactivation of the phagocytic cells of immune system, production of nitric oxide by the vascular endotheliums, vascular damage caused by ischemia reperfusion known as ischemia/reperfusion injury and, release of iron and copper ions from metalloprotein.

The unusual incidence of ALS (amyotrophic lateral sclerosis) among Gulf War veterans deserves mention. The Institute of Medicine study confirmed that veterans were at greater risk of contracting Lou Gehrig's disease than the general population. ALS is very rare. Only five cases are diagnosed for every 100,000 persons. The incidence was between two and three times greater among soldiers deployed in the Gulf. Under normal conditions, ALS is diagnosed late in life, after age 55. Veterans suffering from the disease were much younger. In two-thirds of 40 documented cases, victims were between 20 and 54 years old (Bertell, 2006).

Before constructing a profile of the toxic effects of uranium, a few preliminary points require emphasis. As already stated, of the uranium that is absorbed into the body from the lungs and the intestines, 67 to 90 percent is rapidly excreted in the urine. The remainder is sequestered for varying lengths of time in the skeleton, kidneys, liver, brain,

testes and other tissues (WHO). [In rats implanted with pellets of DU, uranium was noted as concentrating in the heart, lung tissue, ovaries and lymph nodes (Arfsten *et al.*)]. Of that fraction retained within the body, tremendous uncertainty exists as to its physiological impact. Although the propaganda machine pretends that the toxicology of uranium is well understood, there are sufficient gaps in the knowledge base to warrant concern and caution. Drawing attention to this point, a publication from the Institute For Energy and Environmental Research (Makhijani and Smith 2004) includes the following observations:

> Surprisingly there are still substantive gaps in knowledge of the non-radiological health impacts of exposure to uranium and its compounds (National Research Council 2003).
>
> Although most of the DU absorbed in the body is metabolized and excreted, enough is distributed throughout the body to raise important toxicological concerns. The long term effects of DU still have to be definitely resolved, and there is an obvious need for continued studies (Craft *et al.*).
>
> In its 2001 review of depleted uranium, focusing in particular on the impact of military munitions, the World Health Organization concluded that there is inadequate information available concerning the potential impact of uranium in the following areas, and that additional research needs to be undertaken:
> - Neurotoxicity: Other heavy metals, e.g. lead and mercury, are known neurotoxins, but only a few inconsistent studies have been conducted on uranium. Focused studies are needed to determine if DU is neurotoxic.
> - Reproductive and developmental effects have been reported in single animal studies but no studies have been conducted to determine if they can be confirmed or that they occur in humans.
> - Hematological effects: Studies are needed to determine if uptake of DU into the bone has consequences for the bone marrow or blood-forming cells.
> - Genotoxicity: Some in vitro studies suggest genotoxic effects occur via the binding of uranium compounds to DNA. This and other mechanisms causing possible genotoxicity should be further investigated (WHO).

Quite obviously, Gulf War disease is a systemic disease. In light of this, it is interesting to note the results of a literature search undertaken during the writing of the *Toxicological Profile for Uranium*:

> No human studies were located regarding the cardiovascular, musculoskeletal, endocrine, metabolic, dermal, ocular, body weight, or other systemic effects of elemental uranium following acute-duration inhalation exposure. Nor were any human studies located regarding the respiratory, hematological, cardiovascular, gastrointestinal, musculoskeletal, hepatic, renal, endocrine, metabolic, dermal, ocular, body weight, or other systemic effects of uranium following intermediate-duration inhalation exposure. No studies were found regarding the cardiovascular, gastrointestinal, musculoskeletal, renal, endocrine, metabolic, dermal, ocular, body weight, or other systemic effects in humans following chronic-duration inhalation exposure. The existing human data on the respiratory and hepatic effects of uranium are limited to acute- and chronic-duration inhalation exposures, hematological effects are limited to chronic duration inhalation exposure, and gastrointestinal and renal effects are limited to acute-duration inhalation exposure. No animal studies were located regarding the endocrine, metabolic, dermal, or ocular effects of uranium in animals following acute-duration inhalation exposures to uranium. Nor were any studies located regarding the metabolic, dermal, ocular, or other systemic effects in animals following intermediate duration inhalation exposure to uranium. There are animal data for acute-, intermediate-, and chronic duration inhalation exposures to uranium for respiratory, hematological, cardiovascular, gastrointestinal, renal, or body weight effects. However, animal data on hepatic effects are limited to acute- and chronic duration inhalation exposures to uranium (ATSDR).

In 2002, Durakovic, Horan and Dietz published "The Quantitative Analysis of Depleted Uranium Isotopes in British, Canadian and US Gulf War Veterans." In that paper, the authors reported detecting depleted uranium in urine samples of ill veterans who were internally contaminated nine years previously. This research was proof positive that battlefield uranium gained entrance to the body in chemical forms that favored long-term retention. The scientific question which invites investigation is where throughout the body was that uranium deposited and what was its physiological impact? For nine years, the material was emitting radiation and serving as a chronic source of heavy-metal exposure to the body's internal environment. To what extent this contamination contributed to the ill health of those tested is a question that needs to be answered before DU munitions can be said to be medically benign.

Durakovic and colleagues, in a follow-up article, made a first attempt at formulating a model for calculating the initial dose of depleted uranium received by the veterans based

upon the concentration of DU being excreted in their urine. In "Estimate of the Time-zero Lung Burden of Depleted Uranium in Gulf War Veterans by the 24 Hour Urinary Excretion and Exponential Decay Analysis," the authors reported their calculations of 11 test subjects, five of whom had tested positive for DU exposure and six who had tested negative. Of those who were DU-positive, the highest estimated lung burden at time-zero was 0.34 mg. Of those who tested DU-negative, the lowest lung burden was 0.00015 mg. Thus, the DU-positive subjects had over 2,200 times the dose of those who were classified as DU-negative.

Based upon this research, Dan Bishop of IDUST performed a series of calculations to clarify what it means to be contaminated with 0.34 mg of DU (Bishop 2004). Assuming this mass to be comprised of pure UO_2, Bishop calculated that, when divided into spherical particles with a diameter of 2.5 microns, the number of particles produced would be 4.3 million. Taking into account the specific activity of DU, he then determined that each particle would undergo 38 disintegrations per year, each disintegration releasing an alpha particle. In total, within the 4.3 million particles, 160 million alpha disintegrations would occur each year. This is equivalent to 5.2 alpha disintegrations each second. Bishop then figured into his calculations the beta and gamma emissions from the decay products of uranium. With thorium-234 and protactinium-234 in secular equilibrium with the uranium, two beta particles and two gamma rays are released for each release of an alpha particle. Thus, during each second 5.2 alpha particles plus 10.4 beta particles plus 10.4 gamma rays are released. In total, 26 radiation events occur each second. This translates into 800 million radiation events per year. Bishop then engages in some lengthy calculations to determine the number of molecules in each particle and their spatial configuration within each sphere, with the goal of determining how many alpha and beta particles would actually escape the mass in which they are embedded to interact with molecules of the body. He arrives at the conclusion that 0.2 % of the alpha particles, 80% of the beta particles and 100% of the gamma rays reach the surrounding tissue and cause damage. This translates into 0.6 alpha particles, 499 beta particles and 624 gamma rays released each minute. Bishop concludes his calculations with this result: **"Thus the total number of damaging radiation events to penetrate living tissue from a 0.34 mg body burden of depleted uranium will be approximately 1100 events per minute, 1.6 million events per day, or 578 million radiation events per year."** (Note: If 0.34 mg of DU is delivered to the body in the form of nanoparticles, the amount of radiation released to tissue will be substantially greater due to the increased surface area of the total while the reduced mass of each individual particle will allow the escape of a greater percentage of alpha and beta radiation.)

Within the monolithic paradigm of the ICRP, this "dose" is insignificant for the

instigation of cancer, and non-cancerous effects to health are not worthy of consideration. Playing off this dogmatism, it is worth mentioning that a correlation of symptoms exists between survivors of Hiroshima and Nagasaki and ill veterans who served in the Gulf. In a report published in 1961 by Japanese researchers, victims of secondary radiation exposure from the Hiroshima blast reported the following chronic complaints (Bishop 1999):

Constant Fatigue and Lack of Stamina
Skin Rash
Headache
Stiff Shoulders, Numbed Hands and Feet
Poor Memory and Dizziness
Sleeplessness
Nausea
Severe Palpitations
Loss of Weight

In comparison, a publication by the Centers for Disease Control and Prevention entitled "Background Document on Gulf War-Related Research" (CDC 1999) contains these tabulations of symptoms reported by ill veterans who served in Operation Desert Storm.

52,835 Gulf War Veterans in a DVA Persian Gulf Health Registry (PGHR) as of August 1997:

Fatigue	0.5%
Skin Rash	18.4%
Headache	18.0%
Muscle & Joint Pain	16.8%
Memory Loss	14.0%
Shortness of Breath	7.9%
Sleep Disturbance	5.9%
Diarrhea & Other GI Symptoms	4.6%
Other Skin/Integumentary Tissue	3.6%
Chest pain	3.5%

20,000 Gulf War Veterans in the DOD Comprehensive Clinical Evaluation Program (CCEP) through April 1, 1996:

Joint Pain	49%
Fatigue	47%
Headache	39%
Memory Loss	34%

Sleep Disturbance	32%
Skin Rash	31%
Difficulty Concentrating	27%
Depression	23%
Muscle Pain	21%
Diarrhea	18%
Shortness of Breath	18%
Abdominal/Gastrointestinal Pain	17%
Hair Loss	12%

<u>284 UK Gulf War Veterans in Ministry of Defense Medical Assessment Program:</u>

Muscle & Joint Pain	35%
Tiredness	55%
Short-term Memory Loss	22%
Sleep Disturbance	24%
Skin Problems	16%
Irritability	29%
Tingling in Limbs	11%
Breathlessness	21%

Efforts that are draped in the raiment of scientific research but actually designed to obstruct understanding abound. A classic example is the DU Medical Follow-up Program, initiated in 1993-1994 by the Department of Veterans Affairs (DVA) and the Department of Defense (DOD). The scientific value of this project is worth evaluating because it has taken center ring in the US government's effort to prove to the world that DU exposure produces no ill effects. The veterans participating in this research initiative are survivors of the 20 or so friendly fire incidents of the first Gulf War which involved US forces mistakenly firing DU munitions at their comrades riding in Abrams tanks and Bradley fighting vehicles. These individuals became candidates for study because their exposure to DU could be **documented** (McDiarmid *et al.* 2006).

Full stop!

Documented? What means this word "documented?" To penetrate to the depth of the corruption infesting the DVA/DOD study of depleted uranium, this word must be dissected. As with everything else about DU, the devil is in the details.

A number of articles have been published by McDiarmid and her associates over the years documenting DVA/DOD medical surveillance of DU effects on Gulf War veterans. Some of these articles report on the ongoing surveillance of those veterans involved in friendly fire incidents. Other articles report on the surveillance of veterans who voluntari-

ly applied for medical assessment, *believing* themselves to have been exposed to DU while serving in the Gulf. The exposure of these veterans has never been objectively validated, i.e., documented. This distinction perpetuated by DVA/DOD between documented and undocumented exposure is fascinating in its guile and leads straight to the government's cover-up of DU effects.

At the outset of the DVA/DOD DU Medical Follow-up Program, 33 veterans were enrolled. (By 2006, the number had risen to approximately 70.) These veterans were deemed to have had documented exposure to DU. Approximately a quarter carried DU shrapnel in their tissues and the rest were involved in friendly fire incidents and were presumably exposed. To document the level of uranium exposure among victims of friendly fire by supposedly objective and scientific means, a diagnostic test was performed that measured the total concentration of uranium in their urine from a 24-hour urine sample. Unremarkably, a major finding was that, with the odd exception, the only veterans excreting elevated levels of uranium were those with embedded shrapnel. The rest of the study group was excreting uranium at levels that were comparable to the general, unexposed population. Those veterans under surveillance were then divided into two groups, a high-exposure group and a low-exposure group, based on the concentration of uranium in their urine. Medical follow-up was then performed periodically over the next decade. The basic procedure of this study became the standard for all future studies conducted by the US government when assessing DU exposure. The measure of total uranium became the benchmark for assessing DU exposure and "documenting" which veterans had been contaminated with depleted uranium.

Nearly three-quarters of the veterans from friendly fire incidents do not carry embedded shrapnel in their bodies. But numerous questions remain unanswered about their exposure. No information is provided on the nature of the friendly fire incidents in regards to what type of munitions were involved and the amount of DU that was liberated. More importantly, although those being studied were involved in these incidents, no information is provided as to whether they actually ingested or inhaled DU. The only information published is that they are excreting uranium within the normal range. Without analysis of the relative concentration of the isotopes of uranium they are excreting, there is no way to know if they were exposed to DU and to what extent.

Within the human body, uranium serves no biologically useful purpose. Consequently, when internalized, its uselessness and potential toxicity is recognized, and the body works to rapidly excrete it. For those with metal fragments in their tissues, their heightened uranium burden remains immobilized, locked within the mass of each piece of shrapnel. However, on an ongoing basis, uranium on the surface of these fragments dis-

solves and migrates to the systemic circulation. A small percentage of this uranium is delivered to the tissues of retention while most is rapidly filtered from the blood by the kidneys and excreted in the urine. The measure of total uranium for these individuals remains elevated for years or decades due to the ongoing presence of this soluble fraction of uranium perpetually mobilized in the body.

But what about the hundreds of thousands of other veterans who served in the Iraqi theater of war? Their exposure to DU, if it occurred at all, is not known. Why? On the battlefield, if a veteran inhales sufficient quantities of DU, the soluble fraction will rapidly enter the circulation. The fact that exposure did occur will be reflected by an elevated concentration of uranium in the urine. For a short window of time, days to a few weeks, elevated levels of uranium will be capable of being detected while the body is in the process of eliminating it. However, if total uranium is measured many weeks, months or years after exposure, the results will invariably fall within the range of the normal, unexposed population due the the body's efficient process of elimination. At that point, measuring total uranium will provide **NO** evidence of DU exposure. This does not mean that these soldiers have eliminated all battlefield uranium from their bodies. They may still be harboring significant quantities of ***insoluble*** uranium in their tissues but due to the slow dissolving of this fraction, the total concentration of uranium in the urine will not be elevated beyond the normal range.

Quite obviously, with the passage of sufficient time after the exposure event, the measure of total uranium is the wrong diagnostic test to confirm DU exposure. So what happens when a veteran applies for medical assessment years after service? A urine sample is collected and the total concentration of uranium is measured. The results inform the veteran that he is excreting uranium at the same levels as the average man on the street and no evidence exists that DU is in his body or that DU may be affecting his health. If battlefield uranium remains in his tissues, it will be hidden by lies. For the DVA/DOD medical surveillance program conducted years after the war, the only veterans whose exposure to DU will be able to be documented are those who carry embedded DU shrapnel. For all other veterans, regardless of what quantity of DU they internalized on the battlefield, their exposure cannot be documented. A simpler cover-up could not be conceived. Rely exclusively on the wrong diagnostic test, and a whole army's exposure can remain undocumented.

The methodology of DVA/DOD is sneaky, underhanded and fraudulent. Hidden behind its stated intent of investigating DU exposure, its real purpose is to keep the true extent of DU exposure among those who served in the Gulf undocumented. As for veterans who are suffering from an unidentified illness, this methodology guarantees to return

results which discount DU exposure as a possible causative factor. If DVA/DOD were conducting research in good faith, they would perform the correct diagnostic test. To objectively document DU exposure, the test that is required is one that measures the ratio of the different uranium isotopes present in the urine. Only by this means can the unnatural ratio of uranium-238 to uranium-235 caused by the presence of DU be detected. But DVA/DOD cannot afford valid scientific methods. To protect cherished weapon systems, ignorance must reign supreme. DVA and DOD deny that DU is a hazard. DVA and DOD deny that DU contamination is a common occurrence on the contaminated battlefield. DVA and DOD deny that inhalation is a significant route of exposure. To further this disinformation campaign, DOD has initiated a crusade to cast doubt on the reliability and accuracy of accepted, peer reviewed methods capable of determining the ratio of uranium isotopes in urine drawn from veterans who were exposed to DU years earlier (Winkenwerder). By sowing doubt in these analytic techniques, DVA/DOD are attempting to undermine the validity of the only available means so far developed to objectively document previous DU exposure. Standing firmly by their disparagement of peer reviewed science, DVA/DOD fervently adhere to the position that the only valid diagnostic criterion for DU exposure is the measure of total uranium. Given this political position, the only group left to study whose DU exposure can be documented are those who were injured by friendly fire. This is why these soldiers are the centerpiece of the DVA/DOD medical surveillance follow-up program.

The strategy pursued by DVA/DOD in their epidemiology is more complex than simply conducting the wrong diagnostic test. Their research is grounded on two unverified conjectures. The first is that uranium introduced into the body via shrapnel is representative, both physiologically and biochemically, of all types of DU exposure. As mentioned previously, the uranium locked within fragments of shrapnel is isolated from the body. The only fraction of significance is that on the surface of the fragment. Local effects to tissue in the immediate surrounding may be medically significant and require investigation. Thus, those injured by shrapnel form a special group worthy of investigation. But is their situation representative of people who inhaled depleted uranium? This extremely important scientific question remains uninvestigated by DVA/DOD. Veterans carrying DU shrapnel in their tissues have ongoing leaching of soluble uranium from the fragments into the bloodstream. This is why the measure of total uranium in their urine remains elevated for years. But no proof has been provided by DVA/DOD that this uranium is physiologically equivalent to hundreds of thousands or millions of embedded micro- and nanoparticles of insoluble uranium lodged for years or decades in the lungs, the tracheobronchial lymph nodes, the brain and so forth. Without proof of equivalence, the research of DVA/DOD is woefully incomplete and can offer no definitive conclusions about DU's effect on health. At best, their research must be seen as research on DU shrapnel victims

and their conclusions only valid for this special group.

The research of DVA/DOD rests on a second unverified conjecture. Their work assumes that no adverse physiological effects are produced by uranium unless the total concentration of uranium in the urine is sufficiently high to produce observable structural and functional changes to the kidneys. Certainly, there is a body of dated research that may justify adherence to this premise, but such adherence precludes exploring the possibility that there are aspects of uranium's toxicity that have yet to be discovered. The whole strategy of DVA/DOD to discount any ill effects of DU is based on the supposition, which may now be antiquated, that unless kidney damage is evident, uranium is producing no other damaging effects in the body. This is why their evaluation of veterans is confined to measuring the total concentration of uranium in the urine. This test is only a means of quantifying possible toxicity to kidney structure and function. If total concentration of uranium falls below the level that produces kidney damage, the veteran is declared unharmed by uranium. There is something disingenuous about this diagnostic strategy. The use of DU on the battlefield has produced a novel form of internal contamination with uranium. No precedent exists to establish that the toxicity of inhaled insoluble micro- and nanoparticles is first evidenced by pathological changes to the kidney. A new contaminant with unique biokinetic properties is being delivered to the body. That total uranium in urine is within the normal range and that no kidney damage is evident is not sufficient to definitively conclude that this uranium is not producing adverse physiological consequences of other kinds.

Ted Weyman, field team leader for the UMRC studies in Afghanistan and Iraq, has written an important report regarding DVA/DOD's position on uranium in urine. In "Abu Khasib to Al Ah'qaf: Iraq Gulf War II Field Investigations Report," Weyman states the following:

> Although US-led Coalition-members' and NATO defense departments acknowledge battlefield uranium byproducts, if inhaled, could be a biological hazard, they do not attribute any significance to their findings of DU in those veterans who do not have DU shrapnel wounds. German, Australian, Danish, Canadian and British defense department studies for example, identified abnormally high concentrations of uranium in urine (some finding DU isotopes) of Balkan and/or Gulf veterans. They dismiss the findings by explaining that veterans' urine uranium levels do not exceed the US DOD's expressed reference point: 50 ng (nanograms) of uranium per liter of urine for unexposed populations. They claim the veterans exhibit "normal distributions."

Dismissing elevated urine uranium values in Canadian and European armed forces based on a threshold limit value of 50 ng/liter reveals these countries are ignoring international and domestic occupational and civilian public health regulations. The US public health regulatory baseline for biological background levels of uranium in urine is actually 8 ng/liter; a significant variation from the DOD standard and a distinction they all fail to report to veterans and political oversight committees. UMRC's control sampling shows normal European populations excrete uranium in urine at a rate of 2 to 11 ng/liter. By not comparing veterans' urine uranium values to the US Center for Disease Control's 8 ng/l average for normal populations, EU, Canadian and NATO states' defense departments are ignoring uranium contamination ~ 6 X's the norm.

Misrepresenting clinical and environmental facts allows defense departments to persist at avoiding what they know is the most important step in DU research and clinical follow-up: dose reconstruction by "retroactive differential decay analysis." Dose reconstruction is legislated as the means to determining worker eligibility for health benefits for diseases resulting from exposure to industrial and commercial uranium in the US nuclear sector. Using retroactive differential decay analysis, UMRC has published data showing some Canadian, British and American Gulf War I veterans, whose urine contains trace amounts of DU 10 years after exposure, inhaled sufficient quantities of battlefield uranium to receive an internal dose exceeding the legally permitted radiation dose levels for civilians. External doses at these levels would be unusual and short-lived events, ceasing when the subject departs the source of exposure. Incorporation of uranium by inhalation presents internal radioactive "hot-spots," permanently contaminating organ tissues and bones, and assaulting the chromosomal structure of the DNA. This is clinically established as a condition which can never be escaped and for which there is no known medical treatment.

Defense departments' official policy is to protect their personnel with the same standard as civilians. If they were to reconstruct the dose levels in properly tested veterans with battlefield uranium exposure, they would have to admit to uranium contamination exceeding civilian protection standards — facing litigation by veterans and political pressures to desist from using uranium munitions. If instead, they choose to adopt the more tolerant, "occupational" dose limits, they would become subject to "nuclear employer" status with onerous

> occupational health and safety regimes and pressures to extend radiation protection and exposure control into the battlefield. Controlling battlefield exposure to uranium munitions' byproducts would be impossible without eliminating uranium altogether. This would likely launch them down the slippery slope of accountability for civilian effects in foreign conflict areas.

Inhalation of uranium by large numbers of people is now a fact of life. One would think that the cohort of Gulf War veterans would be the ideal group to study in order to round out understanding of uranium's toxicology. But DVA/DOD are not interested in innovative research that may produce accurate, and potentially inconvenient, conclusions. Their intent is to obstruct understanding of possible DU effects. This is why their study is centered on shrapnel-injured veterans and why they pay scant attention to the inhalation pathway. To DVA/DOD, it doesn't matter by what means or in what forms uranium is delivered to the body's interior. They ignore the insoluble fraction of inhaled uranium. They are oblivious to nanoparticle contamination. Their only interest is in demonstrating that elevated levels of uranium in the urine do not produce damage to the structure or function of the kidneys. Having demonstrated this, they believe the corollary to this finding has also been proven: that people with a measure of total uranium in their urine less than that of shrapnel-wounded soldiers will remain unharmed by DU exposure. According to a DOD summary of their medical surveillance programs:

> The published results of these medical evaluations indicate that the presence of retained DU fragments is the only scenario predictive of a high urine uranium level, and those with embedded DU fragments continue to have elevated urine uranium levels 10 years after the incident. It is unlikely that an individual without embedded DU fragments would have an elevated urine uranium level, and consequently any uranium-related health effects. Those individuals with normal urine uranium levels now are unlikely to develop any uranium-related toxicity in the future, regardless of what their DU exposure may have been in the Gulf War. Those individuals with elevated levels of urine uranium 10 years after the Gulf War have not developed kidney abnormalities, leukemia, bone or lung cancer, or any other uranium-related adverse outcome. The DU Medical Follow-up Program will continue to monitor those individuals with elevated urine uranium levels to enable early detection of any adverse health effects due to their continued exposure to embedded DU fragments (DeploymentLINK).

There is an element of showmanship in DVA/DOD's approach to uranium toxicity

which is intended to have a psychological impact on anyone listening. The implicit message being conveyed by the study of shrapnel-wounded soldiers can be characterized like this: *Okay, if depleted uranium poses any medical hazard, let's study those individuals who have taken the largest amounts of uranium into their body. Soldiers wounded with shrapnel are the study group of choice. If these people who are so heavily contaminated do not have cancer or kidney disease, then surely people who have inhaled much smaller quantities of DU could not possibly have been made ill by uranium.*

The logic of this argument seems unassailable. However, a few pertinent facts are left in the shadows. First, as mentioned earlier, almost all of the volume of uranium in embedded shrapnel remains isolated from the body's vital processes. This is not to belittle the seriousness of a shrapnel injury or the suffering that victims of such injuries endure. But in terms of internal contamination, the only uranium of concern is that which covers the surface of the metal fragments. The uranium deeper within the particles are biologically inactive, sequestered from the body and incapable of doing harm. Over time, uranium slowly leaches from the surface of the shrapnel into surrounding body fluids from where it eventually migrates to the blood. The chronic elevated levels of soluble uranium in this scenario are analogous to the elevated levels found in uranium miners or people with high concentrations of uranium in their drinking water. There is no dispute that the human body can manage higher the average quantities of uranium in this form and that the kidney can excrete it without sustaining significant damage. From a radiological point of view, of all the possible ways for uranium to be delivered to the body's interior, shrapnel is probably the most benign. Depending on the physical characteristics of the internalized metal fragments, a significant fraction of the alpha and beta radiation will be absorbed within the particles themselves and never escape to interact with the body's molecular make-up. Only radiation emitted from or near the surface of the particle will pose a biological hazard. By contrast, grind this mass up into micro- and nano-sized particles, and all of a sudden, the amount of radiation delivered to the body is substantially increased. Further, due to size and shape of shrapnel fragments, the spatial geometry of radiation damage in the vicinity of the fragment is likely to be less concentrated, and hypothetically more benign, than that created around micro- and nano-sized particles. The possibility does exist that uranium shrapnel poses a long-term radiological and chemical hazard to tissues in its vicinity and to the body as a whole. Thus, the DVA/DOD study can be rightly characterized as a study of DU shrapnel injury rather than being misrepresented as a study of DU effects in general. For this reason, its continuation is medically warranted.

The medical surveillance follow-up study discounts any possibility that depleted uranium can pose a radiological risk to the body. This conclusion is based on the corrupted science of the ICRP and the outdated assumption that the only endpoint of concern from radiation exposure is cancer. Later in this chapter, a review of current scientific research

will be presented on the genotoxic, mutagenic, cytotoxic and teratogenic properties of DU. This body of knowledge clearly demonstrates that the radiation emitted by uranium, by acting alone or in synergy with its own chemical effects, can adversely alter cell physiology and biochemistry.

In 2004, the *New York Daily News* funded an investigation of nine ill members of the 442nd Military Police Company who had served in Iraq. Isotope analysis of 24-hour urine samples by means of a mass spectrometer conclusively determined that four of the soldiers were excreting depleted uranium. In some of the others, the presence of DU could not be confirmed, but uranium-236 was detected — an isotope not found in nature but present in DU (*Democracy Now*; Rose). In 2007, two ill veterans from the Australian military who had served in the First Gulf War were found to be excreting DU in their urine 15 years after their exposure (*Sydney Morning Herald*).

Until research is undertaken to determine the presence or absence of DU in the bodies of ill veterans, no amount of propaganda will be sufficient to exclude DU from consideration as a possible factor in their illnesses. But DVA/DOD cannot conduct this research because the results may irreparably conflict with their propaganda. Now, we have a new Gulf War and new incidents of DU exposure. Rather than continue to focus on veterans exposed to DU 15 years ago, what efforts are being made today to assess the impact of new battlefield exposures to uranium? Let's leave it to DVA/DOD to inform us of the strenuous efforts they are making to monitor the health of today's soldiers on the contaminated battlefield.

The Health Effects of Depleted Uranium — General Considerations

Wherever depleted uranium weapons have been fired, soldiers and members of exposed populations have become ill. Gulf War Illness, Balkan War Syndrome, Afghani War Disease are designations for real diseases suffered by real people. DU is the link between the war zones where these illnesses emerged. For those with an inquiring mind, this juxtaposition of possible cause and evident effect demands investigation. Contrary to the propagandists' claim, there might yet be things to learn about the biological response to low doses of radiation and the chemical toxicity of uranium.

The introduction of uranium weapons has sparked worldwide interest into their biological effects. Numerous labs have begun to investigate various aspects of uranium's impact on living systems. From these preliminary efforts, the emerging picture shows that

the toxicity of depleted uranium is an extremely complex phenomenon that cannot be adequately accounted for within the confines of the ICRP model of radiation effects and what has been learned from more traditional forms of uranium exposure. DU weapons produce a novel form of internal contamination, and they are either a factor or cofactor in the initiation of a unique disease process. The debris generated by DU weapons is both radioactive and chemically toxic and is delivered into the body, via inhalation, as micro- and nano-sized particles. In these forms, uranium and other heavy metals associated with DU weaponry migrate to various sites in the body and exert ongoing chemical, radiological and nanoparticle effects. The problem facing medical researchers is to determine how the multifaceted nature of DU's toxicity works synergistically on the numerous sites within the body to produce a systemic manifestation of disease.

A fundamental obstacle to understanding the implications to health of depleted uranium is the ICRP model of radiation effects. The dominance of this paradigm dissuades researchers from considering that radiation can produce non-cancerous effects deleterious to health. On the subject of Gulf War Disease, one can easily spot the apologist for depleted uranium weapons by a declaration such as this: "The dose of radiation from internalized uranium is too small to induce a cancer." Cancer? The subject being considered is not cancer. It is an entirely different disease process. So why bring up the subject of cancer? On the subject of depleted uranium and its connection to Gulf War Disease, the ICRP model has nothing to say. It has marginalized itself to the point of irrelevance because it denies that radiation can impact the human body in any other way than by inducing cancer. That uranium's radioactivity may work in synergy with uranium's biochemistry to produce noxious effects is beyond its purview. On the subject of DU's radioactivity, the powers that be have nothing to contribute to the discussion except the stale mantra "the radiation dose from DU is too small to cause cancer."

The tyrannical stranglehold on truth perpetuated by ICRP models has not smothered all research on low-dose, low-level radiation. And not surprisingly, this research clearly indicates that uranium is quite capable of inducing deleterious effects to health. In an article entitled "Is It Safe to Live in Territories Contaminated with Radioactivity," written in reference to Chernobyl, Burlakova and Nazarov review aspects of their *in vitro* and *in vivo* experiments which were designed to investigate the relationship between radiation dose and biological effect. They describe their research as follows:

> We investigated the structural parameters of the genome (by the method of DNA binding to nitrocellulose filters), structural parameters of nuclear, microsomal, mitochondrial and plasmic (synaptic and erythrocyte) membranes (by the method of spin probes localized in

> various layers of membranes), the composition and oxidation degree of membrane lipids, and the functional activity of cells — the activity of enzymes, relationships between isozymic forms and regulating properties.
>
> We also investigated the effect of low-level irradiation on the sensitivity of cells and biopolymers to subsequent action of various damaging factors, including high-dose irradiation. The animals were exposed to a source of Cs137 gamma-radiation at the dose-rates of 41.6×10^{-3}, 4.16×10^{-3}, and 0.416×10^{-3} mGy. The doses were varied from 6×10^{-4} to 1.2 Gy.
>
> As a result of the studies performed, the following conclusions were made;
>
> 1. The dose dependence of the radiation effect may be **non-linear**, **non-monotonic**, and **polymodal** in character.
> 2. Doses that cause extreme effects depend on the irradiation dose-rate (intensity).
> 3. **Low-dose irradiation causes changes (mainly enhancement) in sensitivity to the action of other damaging factors**.
> 4. The effects depend on the initial parameters of biological objects.
> 5. **Over certain dose ranges, low-level irradiation is more effective with regard to the results of its action on an organism or a population than acute high-level radiation** [emphasis added].

In the course of their research, Burlakova and Nazarov observed that the dose-effect relationship at different doses and different dose rates was non-linear, non-monotonic and polymodal. They explain that these differences result from changes in the relationship between the damages produced by the radiation and the mechanisms called into play to repair the damages. The surprising discovery that an enhanced hazard is produced by low-level radiation over certain low-dose ranges stems from the fact that reparative systems are either not initiated, function inadequately or are initiated after a delay when structural/functional damages have already occurred. To explain why observed high-dose effects are different from those of low doses and why observed biological effects from high doses cannot successfully predict effects at low doses, the authors offer this explanation:

> It is difficult to predict the dose dependence for the effect, which is a result of the interaction of several subsystems, when each of the sub-

> systems is sensitive to a certain factor and exhibits its own characteristic response to increasing dose.
>
> Generally speaking, one can hardly expect a monotonic increase in the resulting radiation effect with increasing dose because the determining factor here is not solely the reaction of each individual subsystem but the sign (direction) and character of their interaction.
>
> In particular, the experiments showed that the radiation effect on an organism, along with its direct action on the structural and functional biological subsystems, mobilizes and activates the protective systems of reparation, adaptation, etc., whose regulating role is compensation and minimization of the direct irradiation effect, restoration of functions, and repairing the damages. After the initiation of reparative processes, the resulting (residual) effect depends on the relationship between the direct (irradiation) and reverse (restoration and compensation) processes, which is different for each separate irradiation dose.

As stated, different doses produce different degrees of damage and these elicit different reparative responses. To demonstrate that reparative processes within specific dose ranges fail to adequately counter radiation-induced damage, the authors mention a number of examples. For instance, they report on experiments which demonstrate that on the cellular level, irradiation at certain low doses fails to activate repair mechanisms and the damage remains unaddressed. By this phenomenon, exposure to low doses may introduce more harm to the system than that produced at higher doses when reparative systems respond to the radiation insult.

The complexity of the dose-response relationship at different dosages is highlighted by Burlakova and Nazarov in a discussion of radiation-induced oxidative stress. Radiation produces reactive oxygen species which damage biomacromolecules such as DNA, proteins and lipids and erode the structural/functional integrity of membranes. But also, reactive oxygen species participate in normal metabolic processes and in regulating processes in cells responsible for division, proliferation (reproduction), differentiation and apoptosis (programmed cell death). Under these circumstances, it is the balance or lack thereof among damage, repair and dose which ultimately determines the consequences to healthy function from radiation exposure. According to the authors:

> It is difficult to predict the resulting overall response of a cell without the knowledge of the response of each of its systems and their dependence on the intensity, mode and dose of irradiation and the overall nature of their radiosensitivity. However, it is possible to make

> a general conclusion that the resulting response of an organism, cell or population will depend, to a large extent, on the balance of opposite processes, e.g., apoptosis and proliferation.

Burlakova and Nazarov explored trends in the variation of three parameters related to extreme points on the dose-dependence curves: (1) time during which the effect reaches the maximum, (2) dose at which the maximum is reached, (3) the effect at the extreme points, depending on the irradiation intensity, which varied by an order to two orders of magnitude (from 0.06 to 0.6 and 6.0 cGy). They report the observed changes in DNA and membrane structural parameters as follows:

> From rates of change in the DNA structural parameters we determined that a decrease in the irradiation intensity results in an increase in the time of the effect reaching its maximum, a decrease in the dose of the maximum effect, and a decrease in the effect at the extreme point. Similar trends were determined for nearly all parameters of membranes. **Exceptions were the data obtained for the lowest irradiation intensity, at which maximum effects were observed**. With regard to the fact that the maximum effects are observed at the time of initiation of the reparative systems, the trends we determined make it possible to conclude that the lower the irradiation intensity, the later the reparative systems are initiated. The results obtained are evidence for a high biological activity of low dose irradiation and different mechanisms on the cell metabolism than those for high doses [emphasis added].

In this discussion, the reader should recall that much attention has been given to radiation-induced hormesis and the beneficial aspects of low-dose, low-level exposure. The work of Burlakova and Nazarov directly contradicts blanket assertions that low-dose exposure is without detrimental effect and is potentially beneficial. Perhaps, as suggested elsewhere in this book, at the lowest doses, enhanced hazard exists while repair mechanisms remain inactive. Hormesis manifests itself only in that dose range where sufficient damage begins to mobilize reparative mechanisms. Then, at higher doses, the reparative mechanisms are again overwhelmed and progressive damage to the organism is produced. Under this scenario, the low doses of depleted uranium could very well produce negative health consequences not currently considered by the reigning paradigm.

Burlakova and Nazarov call attention to research which demonstrates that, after low dose irradiation, living organisms display a heightened sensitivity to subsequent exposures to both radiation and a variety of other damaging agents. They believe these changes result from the radiation-induced instability of the genome. The authors explain this as follows:

> Note that the genome restructuring and, as a result changes in the accessibility of the genetic material to regulating effects, play an important role in these processes. In our work and the work of others, the expression of regulating genes (initiation, induction, or starting functioning) after low-dose low-level irradiation of organisms was observed. These findings are of great importance because changes in the sensitivity to the action of many other damaging factors after low dose exposures may be (and actually are) the cause of diseases and disturbances in the adaptive ability of man. It should be emphasized that these processes are closely related to aging, which is a process also characterized by enhancement of the sensitivity to damaging factors and the probability of death from these factors increases with age.

Finally, Burlakova and Nazarov call attention to the impact of free radicals on DNA and the integrity of membranes. According to their observations, low-level radiation disrupts the regulating functions of membranes and of the genome, while signaling functions between cells that mobilize reparative responses are also disrupted. This is clarified by these observations:

> In this work, much attention is given to free radical reactions caused by irradiation, in particular promotion of oxidation of fats (lipids) and associated changes in the composition and functional activity of membranes, restructuring of the membrane apparatus, increase in the concentration of free radicals in various components of cells, antioxidant activity of regulating enzymes, changes in physicochemical properties and regulation of the activity of the genome (expression and repression of genes).
>
> In experiments in animals and in studies on biochemical parameters of formal elements and blood plasma of man, common trends in the effects of low-dose, low-level irradiation were observed, namely disturbances in the correlations between oxidizability and antioxidant properties of lipids and between structural changes in lipids localized in various portions of membranes. These changes result in a loss of the regulating functions of membranes. Similar trends were observed for structural changes in DNA and the genome. At present, there are many works published that verify the crucial role of the signaling functions of active oxygen species in the regulating network of cell response to damaging impacts, radiosensitivity and instability of the genome.
>
> Therefore, changes in the composition, structure and functional activity

> of membranes are primary symptoms of disturbances in the cell metabolism and a predicting factor in the development of a disease.

The research of Burlakova and Nazarov is refreshing. Rather than restricting the discussion of radiation effects to cancer causation, it realistically addresses the impact of radiation on cell-membrane integrity and the resulting diminution of that membrane's ability to regulate healthy cell functioning. This phenomenon takes on central importance when considering the contribution of radiation to the onset of disease. Not constrained by political agenda, the work of Burlakova and Nazarov is free to entertain the possibility of detrimental low-dose effects. When considering radiation-induced damage to DNA, cancer induction is not the only topic of concern but also the impact to the alternation in gene expression and the detrimental influence to regulating mechanisms both within and between cells. Their work also considers the adequacy of antioxidant defenses in responding to radiation-induced oxidative stress and recognizes the secondary damages induced when these defenses are overwhelmed. Immune system response is also factored in when evaluating the dose-response relationship: the radiation-induced disregulation of this system is recognized as playing a significant role in making the organism vulnerable to other disease-producing agents. None of these biological processes have a place in the ICRP model of radiation effects.

The researcher into DU effects must never lose sight of the fact that uranium and its decay products produce biological damage wherever they are sequestered in the body. With every decay of a radioactive atom, hundreds to thousands of essential macromolecules are damaged. This biological mayhem results from the direct impact on these structures of alpha and beta particles or gamma photons or secondary electrons. As observed by Durakovic: "Structural changes in the molecules include hydrogen bond breakage, molecular disintegration and molecular cross linking. Structural alterations of the molecular integrity lead to functional changes with consequent metabolic changes, which may alter genetic transcription and translation of the macromolecular codes in both DNA and RNA" (Durakovic 1999). Since radioactive decay occurs within the aqueous medium of the body, an abundance of highly reactive free radicals are produced which further induces a cascade of biochemical damage. Further complicating this chaos are possible synergistic effects. One example of the synergy between radiation and heavy metal chemistry is mentioned in the article "Emerging Picture of Uranium's Health Risks:"

> Some research has also provided indications that there may be a synergistic effect between the heavy metal aspect of exposure to uranium and its radioactive effects. Research on the hazards of the heavy metal cadmium indicated a potential synergistic response when expo-

> sures were combined with gamma radiation. Work on these kinds of combined exposures has shown that the direct damage to DNA from radiation exposure was likely combined with an inhibition of DNA repair by certain heavy metals. A double whammy, so to speak (Smith and Makhijani).

"Radiological Toxicity of DU," written by Baverstock, Mothersill and Thorne, was published in 2001. The World Health Organization unsuccessfully attempted to suppress it. Baverstock offered this opinion about the incident:

> I believe our study was censored and suppressed by the WHO because they didn't like its conclusions. Previous experience suggests that WHO officials were bowing to pressure from the IAEA, whose remit is to promote nuclear power," he said. "That is more than unfortunate, as publishing the study would have helped forewarn the authorities of the risks of using DU weapons in Iraq" (Edwards 2004).

The WHO dismissed as "totally unfounded" the idea that the IAEA influenced their decision not to publish the study:

> "The IAEA role was very minor," said Dr Mike Repacholi, the WHO coordinator of radiation and environmental health in Geneva. "The article was not approved for publication because parts of it did not reflect accurately what a WHO-convened group of international experts considered the best science in the area of depleted uranium," he added (Edwards, 2004).

The impotent attempt at censorship by WHO could very well have been motivated by insights within the article that challenged fundamental assumptions of the ICRP model of radiation effects and its ability to realistically address DU's toxicity. Three topics from the article stand out as confirmation that the ICRP propaganda paradigm woefully underestimates the risks to health posed by DU. These are: (1) the enhanced hazard posed by "hot particles," (2) the synergy of uranium's radiological effects and chemical effects, (3) the bystander effect. Consideration of these deficiencies highlights the fact that the concept of "dose" as currently conceived is an inadequate measure for protecting the health of the public.

On the subject of hot particles, apologists for the nuclear industry have traditionally argued that, when compared on the basis of similar organ doses, point sources of alpha-emitting radionuclides do not represent an enhanced hazard over x-ray/gamma irradiation uniformly delivered throughout the same tissue. This position was based on the observation

that alpha particles either killed cells in their vicinity or rendered them incapable of replication, thus eliminating the possibility of mutation in daughter cells and potential carcinogenesis. Recent discoveries have rendered this argument invalid due to bystander effects occurring in proximity to targeted cells. In the case of uranium, chemical effects are capable of compounding the radiological effects to the community of cells responding to each radiation event. On this subject, Baverstock and colleagues offer this observation:

> In the 1970s, there was considerable interest in whether such focal sources of radiation ('hot particles') were of greater concern than homogeneous irradiation of respiratory tissues to a similar average radiation dose. In general, it was found (Burkart and Linder) that such focal sources were no more radiotoxic than uniform irradiation and could be substantially less toxic. The latter result was attributed to cell sterilization effects around the focal sources, as sterilized cells are incapable of reproduction and cannot be the precursors of cancer. However, some caution should be exercised in interpreting the results that were obtained, because the work was largely based on the assumption that only cells that are 'hit' by radiation tracks can be transformed to neoplastic precursors. More recent studies have demonstrated a bystander effect, in which unirradiated cells close to irradiated cell populations can exhibit genetic alterations. It may, therefore, be prudent to examine again the question of whether focal sources of irradiation could induce a spectrum of effects that differs from that induced by more uniform irradiation. In the specific context of uranium, it is of interest also to consider whether the enhanced soluble uranium concentrations that could exist in the vicinity of individual particles or aggregates could interact synergistically with the localized irradiation of tissues, particularly if some of the effects of irradiation are mediated by substances released from the irradiated cells.

According to the authors, inhaled DU is a unique type of internal exposure that cannot be adequately accounted for by current theories of radiation effects. Again, this is due to the enhanced hazard created by uranium's chemical impact on local areas that are simultaneously being targeted by radiation effects. According to the authors:

> The uranium dusts encountered in the milling process may be more insoluble than the dusts generated by burning DU and are almost certainly of different particle size distribution. Burning metal has the tendency to produce sub-micron particles as well as the more usual 1 to 10 micron Activity Median Aerodynamic Diameter particles that

are generally associated with radiological toxicity. Such sub-micron particles present some features that may be significant in evaluating the toxicity of DU (as opposed to natural uranium). These Ultrafine particles may be more soluble in physiological fluids, thus creating a local environment of enhanced uranium concentration in the cells proximal to the particle of DU-oxide. In this respect it is notable that DU-UO_2^{++} cation is capable of transforming human osteoblast cells in culture to a tumorigenic phenotype (Miller, Fuciarelli *et al.* 1998). Similar transformation can be achieved with nickel and, to a lesser extent, with lead, leading to the conclusion that this transformation may have little to do with the radioactivity of DU. This conclusion is confirmed by the small fraction (0.0014%) of cells hit by alpha particles at the uranium concentrations used.

It is relevant to note that nickel is an established carcinogen (IARC) and has been shown to induce a genomic instability similar to that induced by radiation (Coen, Mothersill *et al.* 2001).

Partially soluble dust particles, either because of chemical composition or size, produce a unique situation in which a volume of tissue a few cell diameters in radius, around the particle will be subject to both a relatively high concentration of UO_2^{++} and the occasional alpha particle from decay of the 238U. A 1É m particle of pure 238U weighs 5.8x10-6É g and on average emits 2 alpha-particles per year. Assuming that over a period of weeks half the material dissolves and is retained within a volume of radius 3 cell diameters, or 30É m, the concentration of UO_2^{++} in this tissue volume is about 20É g/g or 0.8 mM – well in excess of the 10É M concentration at which cellular transformation associated with (or leading to) tumor formation in nude mice was seen.

For a total intake of 1 mg of such a dust and assuming that 25% is retained for a long period in the lung of which 50% behaves as a Class M (ICRP 1994) material and dissolves relatively slowly, the remainder being insoluble, there would be about 0.4 x 10^8 such foci with 20% (8 x 10^6) also experiencing one alpha passage in the first month. This is not a situation that has been experienced in any exposure situation for an alpha or any other emitter in the lung. It is not possible to extrapolate the risk of such an exposure from human experience. In particular the risk to the lung of exposure to DU dusts cannot be inferred from the experience gained from uranium miners, or from survivors of Hiroshima and Nagasaki, upon which the current ICRP radiological

> protection standards are based [emphasis added].

The bystander effect bears witness that the ICRP model of radiation effects is stale and out of step with the reality of what transpires in living tissue exposed to radiation. Consequently, all the arguments made in defense of the benign character of internal exposure to battlefield uranium are scientifically implausible. To blithely dismiss DU as a hazard based on the dose of radiation it imparts to tissue is nothing less than quack science. Again, Baverstock, Mothersill and Thorne:

> The implications of the bystander effect also need to be considered in this context. It has been convincingly demonstrated that changes, similar to those caused directly by irradiation, can be wrought in cells growing close to a cell that has been irradiated, or even if they receive activating signals in medium harvested from irradiated cells, even though the changed cells experienced no ionizing event. Such changes include genomic instability, widely associated with the cancer process, and even mutations, also widely believed to be related to cancer induction (Mothersill and Seymour 2001). The basis for this phenomenon is not well understood, but it has been demonstrated that a calcium pulse occurs and resolves within 5 minutes of exposure of non-irradiated cells to medium harvested from exposed cells. Alpha particle radiation is known to be a potent cause of bystander effects, particularly in the form of genomic instability and, since heavy metals can also cause instability (Coen, Mothersill *et al*. 2001), there is a strong case that the mixed radiochemical exposure may be acting in this context.
>
> As directly inflicted DNA damage is precluded as a cause of the bystander effect, it can be inferred that a chemical agent is transmitted from the irradiated cell and that this changes the state of the recipient cell in an apparently irreversible manner. A recent study (Belyakov, Malcolmson *et al.* 2001), using micronucleus formation as an endpoint and a microbeam facility capable passing a single alpha particle through the nucleus of a specific cell, showed a three-fold increase in damaged cells within the environment of the irradiated cell. Typically, 5000 cells were scored with some 100 excess damaged cells. However, excess affected cells were found at distances of mm from the irradiated cell and thus the number of potentially affected cells per particle can be very large. Within 1 mm radius of the irradiated cells there are approximately 10^6 cells, thus if the same ratio of affected cells applied some 2 x 10^4 could be affected.

> The bystander effect is predominant at low tissue doses, where few cells experience an alpha particle passage. At higher doses, recipient cells increasingly experience alpha passages themselves, with a high probability of cell killing and almost certainty of inducing other changes, thus reducing the relative effectiveness of the bystander effect. For this reason, uranium particles, which emit few alphas, would have a greater chance of inducing effects through the bystander mechanism than "hotter" particles [emphasis added].
>
> The implication of the combined chemical and radiological transforming capability of uranium and the bystander effect, means that, in estimating its significance in causing cancer, the simple assumptions, based on committed effective dose, i.e., (committed absorbed dose to the lung, modified by a radiation weighting factor for the fact that the radiation arises from alpha particles) as has been adopted in recent reports by the Royal Society (Royal Society, Part I), the WHO (WHO, 2001) and UNEP (UNEP, 2001) would be an inadequate basis for predicting risks.

The "Radiological Toxicity of DU" makes one further point that deserves consideration. As noted earlier in this chapter, a common argument put forth in defense of DU is that adverse effects to the kidney are the gauge by which all other adverse physiological effects from internal contamination are to be measured. If exposure to DU produces no abnormal structural or functional alterations to the kidney as a result of uranium's chemical nature, then it can be assumed that no other negative physiological effects will occur. Baverstock, Mothersill and Thorne indicate that this "assumption" might very well be erroneous:

> The usual assumption, based on the specific activity of uranium, standard tissue and radiation weighting factors (ICRP 1991) and the distribution of uranium between different tissues, is that impairment of kidney function will always be more important that any carcinogenic effect. This assumption can, however, be questioned on two grounds, namely the potential for synergy between chemical and radiation toxicities, and the bystander effect, as discussed above.
>
> In the experiments with osteoblasts (Miller, Blakely *et al* 1998), the concentration of UO_2^{++} was 10É M, which is close to the 0.3É g/g level in the kidney assumed to be below the threshold for toxic effects. In the transformation assay, this produced a 10-fold increase in the tumorigenic phenotype with about 1 in 10^5 cells being hit by an alpha

> particle. It is feasible to explain the transformation in the osteoblasts by the bystander effect alone, but the similar level of transformation brought about by the same concentration of nickel ions cannot be explained radiologically.
>
> If there is indeed a synergistic effect between the chemical and radiological properties of uranium, why is exposure to naturally occurring uranium apparently without radiological health consequence? One answer to this question is that natural uranium is almost entirely ingested. The fraction of even soluble uranium crossing the GI tract is low (typically around 0.02, see ICRP Publication 69 (ICRP 1995)), most being excreted in feces. In the occupational context, the primary route of entry will be inhalation of aerosols. Where the uranium is soluble, the transfer to blood of deposited material is rapid and complete (ICRP 1995). Potentially much higher body burdens could be acquired in this way.

The disruption of normal biochemistry by DU's radioactivity does not occur in isolation. As a heavy metal uranium is also chemically toxic, and via chemical interactions can induce structural and functional damage to cells and their molecular components. Two major pathways are responsible for this toxicity. First, soluble uranium species or uranium on the surface of micro- and nanosized particles can catalyze chemical reactions which produce free radicals. These free radicals, in turn, can induce a cascade of chemical chaos in their immediate vicinity. Second, uranium can chemically bind to biological molecules such as proteins, enzymes and DNA. These adducts may be rendered incapable of participating in normal physiological processes or may induce undesirable chemical reactions. Of particular significance to cellular well-being is uranium's affinity to bind to DNA. This phenomenon can disrupt protein synthesis, gene expression, and DNA replication. Metal atoms binding to DNA can activate DNA repair processes. If this repair is not completed prior to DNA replication, possible effects are nucleotide substitutions, deletions and chromosome rearrangements. Uranium has been proven to chemically produce these types of mutations. This will be discussed below.

The radiological and chemical toxic effects of inhaled battlefield uranium occur simultaneously and are further compounded by the toxicity of nanoparticles. A proof of this concept was first demonstrated in 1955 in a report entitled "Relation of Particle Size of U_3O_8 Dust to Toxicity Following Inhalation by Animals." Wilson and his associates exposed rats and rabbits to U_3O_8 dust delivered in particle diameters of either 0.5 microns or 2.3 microns. For six hours per day, five days a week, for 26 days, the animals inhaled air in which the micro-sized particles were suspended. At the conclusion of the experiment,

greater toxic effects were discovered among the animals inhaling the smaller-sized particles as measured by several parameters of uranium toxicity, including kidney and lung damage.

Upon entering the body, combustion-derived nanoparticles can promote an inflammatory response (Donaldson *et al.* 2005). The underlying mechanism responsible for this effect is free radical production by the nanoparticles which drives oxidative stress. According to Günter Oberdörster and his colleagues:

> *In vitro* studies using different cell systems showed varying degrees of proinflammatory and oxidative-stress-related cellular responses after dosing with laboratory-generated or filter-collected ambient UFPs [ultrafine particles]. Collectively, the *in vitro* results have identified oxidative-stress-related changes of gene expression and cell signaling pathways as underlying mechanisms of UFP effects, as well as a role of transition metals and certain organic compounds on combustion-generated UFPs. These can alter cell signaling pathways, including Ca signaling and cytokine signaling (Oberdörster *et al.* 2005).

According to the prevailing model, the inflammation and oxidative stress created by nanoparticles are mediated by several primary pathways: (1) When a nanoparticle is in immediate contact with a cell membrane, the physical and chemical characteristics of its surface produce oxidative stress. This stimulates increased intracellular calcium, oxidative stress within the cell and gene activation. (2) Nanoparticles can release transition metals from their surface while in close proximity to a cell. In response to the presence of this metal and the oxidative stress it induces, the cell undergoes the same effects: increased intracellular calcium, oxidative stress within the cell and gene activation. (3) Transition metals from nanoparticles can activate cell surface receptors which in turn signal gene activation. (4) Nanoparticles can gain entrance to the interior of cells by phagocytosis and other mechanisms. Their presence in the cytoplasm, in organelles or in the nucleus can be disruptive to cell function through inducing oxidative stress. Although nanoparticles have been observed throughout the interior of cells, they have an affinity for mitochondria. (As noted by Oberdörster *et al.*, "Because mitochondria are redox active organelles, there is a likelihood of altering ROS production and thereby overloading or interfering with antioxidant defenses.") By all four pathways mentioned, the end result is gene activation which produces inflammatory mediators which, once released from the cell, promote inflammation (Donaldson and Tran 2002; Oberdörster *et al.* 2005).

The body's first line of defense from the invasion of foreign substances is the innate immune system. Able to monitor the molecular patterns present on the surface of the diverse components within the body, this system is designed to discriminate between what

is self and what is alien. When foreign substances are detected, inflammatory and defensive responses are initiated. Among first responders are macrophages which track down intruders and make first contact. Under normal circumstances, macrophages respond to alien substances in specific ways depending upon which pattern recognition receptors located on their surface are activated. Each type of receptor triggers expression of different proinflammatory cytokines and anti-inflammatory mediators to counter potential adverse threats. Recent research has revealed that this sophisticated system can be disrupted by the presence of nanoparticles. Nanoparticles, depending on their chemical makeup, have the capacity to wreak havoc with normal macrophage function and immune response and compromise their effectiveness in defending the body from other threats. This nanoparticle effect was reported by Lucarelli, Gatti *et al.* in "Innate Defense Functions of Macrophages can be Biased by Nano-Sized Ceramic and Metallic Particles." The researchers made the following discovery: "exposure to different nanoparticles can modulate, in different ways, the defense/inflammatory capacities of macrophages." According to the authors, nanoparticles can, by their chemical composition, activate different macrophage receptors. As a result of this process, nanoparticles compromise the ability of macrophages to carry out their defensive functions. This compromise of the immune system can occur in the absence of observable systemic effects. As the authors note: "Thus, despite the lack of macroscopic, mechanical inflammatory effects, nanoparticles of metallic or ceramic materials can profoundly modulate the innate/inflammatory response of macrophages." Among the possible effects resulting from the immune response in disarray is chronic inflammation and autoimmune-like diseases:

> Of particular relevance is the possibility that the functional anomalies of the innate immune system caused by nanoparticles may be among the causes of the dysregulated amplification of the immune response and concomitant chronic inflammation characteristic of autoimmune diseases. On the other hand, down-modulation of inflammatory innate receptors and cytokines may hamper immune surveillance and allow tumor development.

Combustion-derived nanoparticles are known to produce an illness known as welding-fume fever. Although never considered in this relation before, this condition may shed some light on uranium weapon disease. Donaldson and his research associates characterize welding-fume fever as follows:

> Exposure to welding fume has been associated with both pulmonary and systemic health endpoints. These include decreases in pulmonary function, increased airway responsiveness, bronchitis, fibrosis, lung cancer and increased incidence of respiratory infection; in addition to

> these pulmonary effects metal fume fever is frequently observed in welders. This systemic condition is considered to be caused by inhalation of zinc oxide fumes and it is characterized by acute onset of a flu-like illness accompanied by a dry cough, dyspnea, muscle aches, headaches and fever. Metal-fume fever is usually experienced in the first periods of exposure and on Mondays, with the symptoms declining as the working week progresses. Welding fume has been studied in both animals and in cells in culture, and in both it produces marked proinflammatory effects. These effects are driven largely by the transition metals which undergo redox-cycling resulting in oxidative stress (Donaldson *et al.* 2005).

What is interesting in this description of the flu-like illness produced from the inhalation of metal fumes is that it is markedly similar to the illness described by Afghani civilians who were sickened by exposure to the debris generated by the detonation of uranium weapons. The Uranium Medical Research Center dispatched a field team to Afghanistan in the wake of US bombing. People living in proximity to craters which tested positive for the presence of non-depleted uranium reported developing a flu-like disease soon after inhalation of bomb debris. Nosebleeds, nasal congestion, respiratory problems, a burning sensation in nose and throats, headaches, memory problems, joint pains were the types of symptoms reported. A reasonable working hypothesis is that the mysterious illness appearing immediately after exposure to uranium weapons is a type of metal-fume fever initiated by the inhalation of metallic nanoparticles. One marked difference exists however between welders and victims of uranium weapons. Welding-fume fever is transitory. Its effects rapidly diminish. The experience of Afghani civilians is the direct opposite. The immediate flu-like illness was the initiation of chronic health problems that persisted unabated since the initial exposure. Perhaps, some toxic components are present in the fume created by uranium weapons that is absent in welding fume that lingers within the body producing chronic health problems. Perhaps soldiers who report developing a flu-like disease on the battlefield after inhaling the smoke from destroyed targets might be a group deserving special investigation as potential candidates of DU-generated disease.

To fully appreciate the potential chaos introduced by the battlefield inhalation of uranium- and non-uranium-bearing nanoparticles, one needs to visualize the known radiological, chemical and nanoparticle effects and see them working in concert. A contaminated individual may inhale from thousands to millions of micro- and nanosized particles. By numerous kinetic pathways, these particles will be distributed throughout the body. Each will become a point source of irritation and disruption of normal function, producing deleterious effects to its local environment. The molecular structure of a nanoparticle's surface may adversely interact with essential macromolecules, disturbing normal function.

Molecules dissolving from a particle's surface may enhance the concentration of uranium or other heavy metals in the cells in close proximity to the particle, producing local toxic effects. These chemical reactions will not occur in isolation but will be happening within a molecular landscape disrupted by radiation. The formation of nonnaturally occurring toxic compounds, misshapen proteins, hormones and enzymes, cell damage and DNA disturbance are all likely consequences. These centers of turbulence scattered throughout the body and the responses they elicit in damaged cells and the overall effect of this chaos on the immune system may manifest systemically as compromised health.

Two monoliths obstruct understanding as to how DU erodes health: ICRP's corrupted model of radiation effects and the misleading information by the major scientific organizations published in DU's defense. Through intentional mischief, these sources sow confusion in people's minds to keep them from accepting the accumulating evidence of DU's toxicity. If their gospel is set aside, current research clearly testifies that DU is a hazard to health.

<u>Depleted Uranium is Genotoxic</u>

Uranium's affinity to DNA has been known for many decades. It's interesting to note that this property of uranium was exploited for microscopic research. In "Uranium Toxicity Literature", Glen D. Lawrence makes this observation:

> Uranium (uranyl salts) has been used for more than 40 years to stain DNA for electron microscopy. Other stains were favored by electron microscopists, which may be due to the more recent findings (1990s) that uranyl ion can catalyze hydrolysis of DNA (strand breaks) in the presence of light. The binding of uranium to nucleic acids and nucleotides and its catalysis of chemical modification of these molecules would clearly implicate this heavy metal as a cytotoxin.

Numerous studies have confirmed that uranium compounds disrupt DNA integrity. Radiologically and chemically induced aberrations in the chromosomes of somatic cells are a known precursor to cancer and, when occurring in germ cells, can produce birth defects. Uranium's deleterious effect on DNA has been documented as resulting directly from its radioactivity and chemical properties and indirectly through induced oxidative stress.

As an alpha emitter, uranium is a known hazard. According to the Royal Society:

> A single alpha-particle (or a few) has been shown to be capable of inducing essentially any cellular effect that is known from ionizing

> radiation. This includes inactivation of the cell (death by apoptosis or necrosis, or loss of proliferative ability), gene mutations, visible chromosome aberrations, genomic instability and malignant transformation. These include the stochastic events that are commonly assumed to be the primary radiation step in the multistage carcinogenic process.

In his presentation before the European Parliament, Keith Baverstock offered these observations:

> DUO [depleted uranium oxide] is in fact part insoluble and part sparingly soluble. Since 1998 evidence has accrued that human cells exposed in the laboratory to low concentrations of DU exhibit changes characteristic of malignant cells and indeed, when implanted into host animals, will lead to malignancy. In these experiments it seems unlikely, given the low concentrations and the experimental conditions, that this effect is mediated by radiation, but is rather a chemically mediated genotoxicity. The nonradioactive element, nickel, produces similar effects and is an established carcinogen.
>
> In 2001 this evidence led me to believe that inhaled DUO particles, which are capable of penetrating the deep lung (where they would be retained for long periods) posed, for a period of weeks to months, not only a radiotoxicity risk but also a chemical genotoxicity risk and potentially a synergy between the two. Thus any risk evaluated on the basis of the ICRP recommendations would be likely to underestimate the true risk.
>
> In addition, that DU is only mildly radioactive through alpha emission, raises the possibility of a further risk route mediated by the so-called "bystander effect" Here a single cell "hit" by an alpha particle sends signals to surrounding cells causing them to behave as if they had been irradiated. In circumstances where bystanders predominate (low dose exposure to alpha particles for example) the bystander effect acts to amplify the "radiation effect."
>
> Thus, detailed examination of DUO reveals three potential risk routes in addition to the conventional radiotoxicity caused by direct irradiation, namely, chemical genotoxicity, synergy between radiation and chemical toxicities and a bystander route.

A 1996 study of nonsmoking workers at an *open pit* uranium mine in Namibia detected

significant increase in chromosome aberrations in the circulating lymphocytes of miners when compared to nonsmoking controls. The authors of the study concluded that "these uranium-exposed miners are at an increased risk to acquire genetic damage, which may be associated with an increased risk for malignant transformation" (Zaire *et al.* 1996). In an expanded follow-up study published the following year, Zaire and colleagues investigated reasons for the higher prevalence of cancer among these uranium miners when compared to the general population of Namibia. Seventy-five nonsmoking, HIV-negative miners were compared to a control group of 31 individuals with no occupational history of mining. The study group showed a six-fold increase in uranium excretion in their urine. They further demonstrated a significant reduction in testosterone levels and neutrophil count and a three-fold increase in chromosome aberration. According to the authors:

> Most remarkably, cells with multiple aberrations such as "rogue" cells were observed for the first time in miners; these cells had previously been found only after short-term high-dose radiation exposure, e.g. from the Hiroshima atomic bomb or the Chernobyl accident. We conclude that the miners exposed to uranium are at an increased risk to acquire various degrees of genetic damage, and that the damage may be associated with an increased risk for malignant transformation. As expected, the chronic radiation injury of the hematopoietic system resulted in low neutrophil counts. Also, low hormone levels probably reflect damage to the gonadal endocrine system (Zaire *et al.* 1997).

In 2003, Heike Schröder and her research associates published a study of 16 British Gulf War and Balkan War veterans who suspected that they had been exposed to depleted uranium. When compared to suitable controls, the study group demonstrated a statistically significant increase in the frequency of dicentric chromosomes and centric-ring chromosomes in peripheral lymphocytes. To clarify this finding, the following explanation is helpful:

> Dicentric chromosomes derive from two DNA double-strand break 'aberrations' in 2 different chromosomes. As a consequence of a false repair, the broken ends of the chromosome arms fuse together and build a chromosome with 2 centromeres, therefore called dicentric chromosome. The cut off endpieces of both chromosomes also fuse and build an acentric fragment. Centric ring chromosomes derive from 2 DNA double-strand breaks within a single chromosome. Again, the broken ends of the chromosomes are misrepaired and form a ring with one centromere. An acentric fragment does also derive. Dicentric and centric rings are most effectively induced by

> ionizing radiation, and their induction results in a dose-dependent manner. Based on adequate calibration curves, this enables dose reconstruction, for example, in the case of an externally applied radiation overdose.
>
> Dic and cR are validated and reliable biomarkers that have been applied to individuals and in population studies over decades. Quantitative analysis of these aberrations is both sensitive and specific in evaluating previous exposure to ionizing radiation. The method is also called "biological dosimetry," and it is the 'gold standard' to prove or to exclude radiation burdens that people have eventually experienced in the past (Schröder 2003).

The findings of Schröder and her colleagues are extremely controversial. The observed chromosome aberration frequency should not have been happening at the "dose" delivered by battlefield DU. According to the authors: "However, as dicentric chromosomes are reliable indicators of ionizing radiation, our findings contradict official releases from the IAEA, the WHO, the MOD and the DOE, stating that the radiotoxicity of DU would be negligible" (Schröder *et al.* 2003). A further bewildering discovery was that the observed chromosome aberrations should not have been so prevalent 10 years after exposure, which was when the veterans in this study were tested. Schröder offers these observations:

> The mean frequency of dic and cR in the veterans' group is 2.5 per 1000 metaphases. Numerically, this indicates a 5-fold elevation among the veterans compared with the control. The difference is statistically significant and the result strongly indicates previous exposure to ionizing radiation for the group as a whole and for at least 50% of the individual members (Schröder 2003).
>
> Assuming a contamination due to ingested soluble oxides of depleted uranium about 10 years ago which would have been excreted with the urine within some few days, and considering the limited half-life of dicentric chromosomes of about 3.5 years following acute exposure to ionizing radiation, the hypothesis of a single acute event 10 years ago is dismissed. It would be implausible to explain the high aberration yield we found in this pilot-study.
>
> However, if the members of our study group had inhaled insoluble, for instance ceramic and very small-sized particles of DU, these might have been deposited and concentrated in their deeper lung and could have delivered considerable doses to the local tissues and to the lymph

> nodes. Local doses from DU may then be persistent and chronic and would accumulate to considerable local doses. This scenario adds plausibility on the cytogenetic findings in the peripheral lymphocytes of the investigated veterans (Schröder 2003).

Other studies have confirmed chromosome aberrations in peripheral lymphocytes among those exposed to depleted uranium. After the conflict in Bosnia and Herzegovina, the United Nations Environment Program dispatched field teams to the battle zone and measured areas of heightened radioactivity at several sites produced by depleted uranium ammunition. One such place in the area of Hadzici, close to Sarajevo, was studied by Krunic *et al.* (2005). Individuals from this area directly exposed to depleted uranium were compared to individuals who lived in West Herzegovina which was not contaminated by DU munitions. Blood samples from the two groups were drawn and the genetic structure of peripheral blood lymphocytes was studied. Results demonstrated an increased frequency of micronuclei in the exposed group.

Alexandra Miller at the Armed Forces Radiobiology Research Institute (AFRRI) has directed a number of *in vitro* studies which has further confirmed depleted uranium's genotoxicity. In one study (Miller *et al.* 2002b), immortalized human osteoblast cells were exposed to depleted uranium, nickel and tungsten. Those cells exposed to DU demonstrated a significant elevation in the frequency of dicentric chromosomes. Cells exposed to the other heavy metals demonstrated no increase in aberrations above background levels. This finding provided evidence that the increased dicentric frequency was induced by DU's radiation. This finding was followed up by exposing cells to three different compounds of uranyl nitrate that had different concentrations of uranium isotopes and, thus, different specific activities. Results showed that the rate in the frequency of neoplastic transformations was directly related to the level of radioactivity of the compound to which the cells were exposed. This again demonstrated that it was DU's radioactivity that was responsible for inducing the observed biological effects. In summarizing their findings, the authors offered the following observation: "Considering that conventional understanding of potential DU health effects assumes that chemical effects are of greatest concern, these results and similar future results could have a significant impact on DU risk assessments."

Another study by Miller and associates was published under the name "Depleted Uranium-Catalyzed Oxidative DNA Damage: Absence of Significant Alpha Particle Decay." This study demonstrated that DU can induce damage to DNA, not through direct impact by radiation, but through promotion of oxidative stress. Once generated by DU, reactive oxygen species then proceed to induce DNA lesions. Important to this finding was the observation that DU catalyzes reactions that induce hydroxyl radicals in the absence of

significant alpha particle decay. The authors propose that these observations can be explained by DU entering into chemical reactions which produce the observed effects:

> While our recent *in vitro* data have demonstrated that alpha particles are involved in DU-induced cellular effects, we also propose that a portion of the transforming mechanisms of DU might be related to its chemical properties. Specifically, DU could participate in cellular biochemistry that generates reactive oxygen species [ROS], OH., O.2, and H_2O_2 similar to the heavy metal nickel (Ni). Alpha particles are high-LET radiation and can cause DNA damage initiated from either direct ionization by the alpha particles or the indirect action of water radiolysis products including ROS. There could be however another DU-induced mechanism to generate ROS. Since uranium chemistry is similar to that of the transitions metals such as iron (Fe) and Ni, we suggest that DU might also catalyze chemical reactions yielding ROS. Specifically, if DU can mimic Fe in the so-called Fenton reaction,
>
> H_2O_2 + MN -complex $\longrightarrow$ MN+1 -complex + OH- + OH.
>
> (M is a metal species), it is likely that hydroxyl radicals from chemical transitions could exceed those from radioactive decay, especially since DU has such a low specific activity.

The authors suggest that chemically generated hydroxyl radicals might exceed radioactively generated hydroxyl radicals by a factor of 10^7. One aspect of this process requires emphasis: "As has been suggested for plutonium, the same atom of DU can recycle indefinitely *in vivo* given ample cellular pools of reductants such as glutathione." In other words, once inside the body, DU might become a source for <u>chronic</u> oxidative stress. The authors make the following observation:

> Our results strongly suggest that DU can participate in chemical reactions generating oxidative stress at physiological pH. Although the concentration of H_2O_2 used in the *in vitro* assay was much higher (100-fold) than the physiological concentration, in an *in vivo* scenario bound DU ions might undergo repeated oxidations and reduction reactions while catalyzing the formation of ROS causing a gradual accumulation of DNA damage. Our results suggest that DU may cause DNA damage through the oxidative pathway.

The article in which these findings were described ends with the intriguing hypothesis that DU may both initiate and promote tumor formation:

> It is tempting to speculate that DU might exhibit both a tumor 'initiation' and 'promotion' component. It has been hypothesized that alpha particle radiation can initiate cancer and the data presented here suggest that DU complexes might contribute to a gradual accumulation of oxidative damage that is important in tumor promotion.
>
> Considering that conventional understanding of potential DU health effects assumes that chemical effects are of greatest concern, results demonstrating that both radiation and chemical effects are involved in DU-induced cellular damage, could have a significant impact on DU risk assessment.

In a third study by Miller *et al.* (2003), colonies of human osteoblast cells were exposed to depleted uranium. The observed effect was a destabilization of the genome in progeny cells which was transmitted from generation to generation — up to 30 population doublings over a period of 36 days. This radiation-induced genomic instability manifested itself as delayed reproductive death and micronuclei formation.

Other *in vitro* studies provide further evidence of the chemical genotoxicity of uranium. An article published in 2005 by Smirnova *et al.* reported observations that uranyl ions were responsible for a high chemical genotoxicity via the generation of reactive oxygen species. A study of the effects of uranyl nitrate in Chinese hamster ovary cells showed a dose-related increase in the frequency of micronuclei, sister chromatid exchanges and chromosomal aberrations (Lin *et al.* 1993). These effects were thought to have been caused through the binding of the uranyl nitrate to the phosphate groups of the DNA. Another study demonstrated that uranyl acetate in the presence of Vitamin C caused single-strand breaks in DNA (Yazzie *et al.* 2003). Research published in 2005 by Diane Stearns and colleagues demonstrated direct interactions between uranium and DNA. The authors concluded that, under the experimental conditions, the covalent bonding of uranium to DNA was a more important mechanism than free radical mechanisms in damaging DNA. In a follow-up study of the two previously mentioned, Stearns and Coryell analyzed the mutations induced in Chinese hamster ovary cells by uranyl acetate. Major genomic rearrangements were observed. The mutation spectrum observed was different from the mutations occurring spontaneously from radiation and from free radical mechanisms. The authors concluded that a distinct chemical interaction between uranium and DNA was responsible for the observed genomic alterations.

In "Genotoxic and Inflammatory Effects of Depleted Uranium Particles Inhaled by Rats," Monleau and colleagues reported that DU inhalations could induce DNA damage in different types of cells in the rat. Cells retrieved from the lung, mostly alveolar

macrophages, demonstrated DNA lesions. Evidence of double-strand breaks was observed, suggesting that radiation could have contributed to the genotoxic effects. DNA lesions were "linked to the dose, independent of the solubility of U compounds while correlating with the type of inhalation." Repeated exposure events were required to produce DNA strand breaks in kidney cells. Aside from radiation, a second pathway to genotoxicity from inhaled DU was observed. Evidence was gathered that inhaled DU particles provoked inflammatory processes and the production of reactive oxygen species (ROS) which together induced lesions in DNA.

This study by Monleau *et al.* highlights knowledge gathered from other sources showing that inhaled nanoparticles initiate an inflammatory response in the host and it is by this means that they produce their deleterious effects. The authors state: "We investigated the inflammatory gene expression in lungs because genotoxicity can be a consequence of the inflammatory response and a relationship between inflammation and tumorigenesis has been shown with poorly soluble dusts" (Driscoll *et al.* 1996). After particles are deposited in the lungs, the two main target cells are macrophages and epithelial cells (Schins and Borm 1999.) Once activated, macrophages secrete pro- and anti-inflammatory cytokines (Driscoll 2000; Driscoll *et al.* 1997) According to Monleau: "The inflammatory response is a key component of host defense but excessive or persistent inflammation contributes to the pathogenesis of disease (Oberdorster *et al.* 1994). Genotoxicity can be caused by direct actions of particles or indirect mechanisms, often mediated by reactive oxygen species (ROS) produced by inflammatory cells (Kirsch-Volders *et al.* 2003; Martin *et al.* 1997)." The integrity of DNA is protected by repair mechanisms and antioxidants. While these are functioning under normal conditions, they provide a threshold to DNA damage. However, as has been mentioned previously, radiation, heavy metal chemistry and nanoparticles can induce oxidative stress that can overwhelm innate defenses and produce genotoxic effects. Monleau *et al.* confirm that DU can be an initiator of this process:

> SOD, catalase, and GPx constitute the main components of the antioxidant defense system and modification in their expression reflects a potential oxidative stress. A study observed that ingested U induces, in mice kidneys, a dose-dependent production of H_2O_2 and an increase in SOD and GPx mRNA levels (Taulan *et al.*, 2004). Such different data suggest that DU can induce oxidative stress.

If for no other reason than to demonstrate that the radiation protection community may not have all the answers as to how radiation damages biological systems, it is worthwhile to present a very tentative and speculative theory, first proposed by Chris Busby in 2005, regarding the enhanced genotoxic effects of uranium. The Secondary Photoelectron Enhancement (SPE) theory proposes a mechanism, not considered by the ICRP model of

radiation effects, to explain how uranium and other heavy metals can pose a radiation hazard independent of radioactive decay. To understand it, some basic radiation physics is required. To begin, when a photon of electromagnetic energy (x-ray or gamma ray) interacts with an atom, its energy is either completely absorbed by an orbital electron (photoelectric effect) or a portion of its energy is transferred to one or more orbital electrons (Compton scattering). If sufficient energy is absorbed by the orbital electron(s), it escapes the atom as an energetic, fast electron. At that point, it is identical to a beta particle and interacts with the surrounding medium by transferring its energy to the orbital electrons of other atoms and producing ionization. The atoms of different elements absorb x-ray and gamma-ray photons with different efficiencies or, perhaps stated more clearly, with different likelihoods. This is dependent on the number of orbital electrons in the atom. According to physical law, elements absorb x-rays or gamma rays in proportion to the fourth power of their atomic number. Relative to hydrogen with one electron (1^4), the stopping power (relative likelihood of absorption) of uranium is 71,639,296 greater (94^4). Thus, when an x-ray or gamma ray passes through the body, it is more likely to be absorbed along its track by an atom with a higher atomic number than by one with a lower atomic number. When it is absorbed and conditions are right, the absorbing atom will emit one or more orbital electrons. **From this it can be seen that heavy metals in the body, radioactive or not, are more likely than lighter atoms to absorb energy from natural background radiation, medical x-rays, or gamma emitting radioactive elements.** In other words, heavy metals in general, and uranium in particular, **amplify** the effect of high-energy photons by stopping them/absorbing them and reemitting ionizing radiation. The importance of this phenomenon should not escape the reader. Heavy metals in the body increase the annual "dose" from natural background radiation by a method not taken into account by current ICRP models. Thus, the effects of otherwise normal types of radiation exposure will be magnified in those individuals contaminated with DU, and this will continue year after year. To quote Busby, uranium particles "will intercept natural background gamma rays and the re-scattered and lower energy electromagnetic radiations from Compton and other processes and act as a secondary photoelectron source for natural background, focusing into points in the body like a magnifying glass focuses the sun."

What makes this proposed phenomenon so important to the genotoxicity of uranium is the fact that uranium has a high affinity for binding to DNA. As previously mentioned, this affinity poses an enhanced hazard to DNA when uranium undergoes radioactive decay. But now we see that uranium acts as a magnet for natural background gamma rays or medical x-rays and focuses this energy onto the DNA. Thus each atom of uranium may have more than one shot at the genetic material to which it attaches. An atom of uranium bound to DNA may never undergo radioactive decay. But this one uranium atom,

over the entire lifespan of a contaminated individual, may have multiple opportunities to fire electrons into the DNA. Eventually, a significant hit may occur.

Busby's theory is intriguing, but requires validation through scientific research. If the phenomenon is shown to have biological importance, its significance may go far beyond the issue of uranium toxicity. SPE may help to explain a mechanism by which other heavy metals sequestered in the body adversely affect health. In this regard, research by Antonia Gatti should be mentioned. By means of electron microscopy, she has examined tumor tissue and has observed bismuth and other heavy metals embedded within it (Busby 2006). The radiation absorbed and reemitted by nonradioactive heavy metals may thus play an important role in tumor formation.

Depleted Uranium is Mutagenic

That radiation induces mutations in DNA is beyond dispute. Radiation protection, as currently conceived, is based on this phenomenon and how it relates to carcinogenesis. What remains in dispute is the quantity of radiation necessary to initiate cancer. What also remains in dispute is what other types of disease, dis-ease and dysfunction can result from radiation exposure. A crooked referee is moderating these legitimate scientific questions. The ICRP, its sister organizations and their corrupted theory of radiation effects conspire to downplay the hazard of radiation so as to divert concern from nuclear and radiological weapons, nuclear power plants and nuclear pollution. Simple testimony can be offered to substantiate this claim. The work of this political cabal disguised in lab coats focuses on "fatal" cancers as the only endpoint of concern to the population from radiation exposure. Grounding their science on this endpoint assures that the impact of human generated radioactivity on public health will be mightily distorted. Rosalie Bertell writes:

> The essential problem is that both the IAEA and the ICRP are dealing not with science but with politics and administration; not with public health but with maintaining an increasingly dubious industry. It is in their interests, and those of the nuclear industry, to play down the health effects of radiation.
>
> RESTRICTIVE DEFINITIONS
>
> The main way in which the "radiation protection industry" has succeeded in hugely underrating the ill health caused by nuclear power is by insisting on a group of extremely restrictive definitions as to what

qualifies as a radiation-caused illness statistic. For example, under IAEA's criteria:

If a radiation-caused cancer is not fatal, it is not counted in the IAEA's figures.

If a cancer is initiated by another carcinogen, but accelerated or promoted by exposure to radiation, it is not counted.

If an autoimmune disease or any non-cancer is caused by radiation, it is not counted.

Radiation-damaged embryos or fetuses which result in miscarriage or stillbirth do not count.

A congenitally blind, deaf or malformed child whose illnesses are radiation-related is not included in the figures because this is not genetic damage, but rather is teratogenic, and will not be passed on later to the child's offspring.

Causing the genetic predisposition to breast cancer or heart disease does not count since it is not a "serious genetic disease" in the Mendelian sense.

Even if radiation causes a fatal cancer or serious genetic disease in a live born infant, it is discounted if the estimated radiation dose is below 100 mSv [mSv = millisievert, a measurement of radiation exposure. One hundred millisieverts is the equivalent in radiation of about 100 X-Rays].

Even if radiation causes a lung cancer, it does not count if the person smokes — in fact whenever there is a possibility of another cause, radiation cannot be blamed.

If all else fails, it is possible to claim that radiation below some designated dose does not cause cancer, and then average over the whole body the radiation dose which has actually been received by one part of the body or even organ, as for instance when radio-iodine concentrates in the thyroid. This arbitrary dilution of the dose will ensure that the 100 mSv cut-off point is nowhere near reached. It is a technique used to dismiss the sickness of Gulf War veterans who inhaled small particles of ceramic uranium which stayed in their lungs for more than two years, and in their bodies for more than eight years,

> irradiating and damaging cells in a particular part of the body (Bertell 1999a).

Research has confirmed that depleted uranium causes mutations in DNA. A number of different outcomes are possible. Occurring within somatic cells, radiation induced mutations may herald the onset of cancer. Such cancers may be fatal. Or they may be survivable, nevertheless causing untold misery to the stricken. Mutations occurring within germ cells may initiate birth defects. When occurring within the developing embryo, they may ultimately lead to miscarriages, stillbirths or congenital deformities. These may also, theoretically, provoke changes to the embryo which will lead, during the course of that human life, to various types of dysfunction and disease. Mutations may alter a cell in such a way as to predispose it to cancer at some future time when further corrupted by other mutagens. Similarly, a cell that has passed through numerous stages on the way to becoming cancerous may finally be tripped into cancer by a radiation-induced mutation.

This last point deserves special mention. Within a few years of the war in Bosnia and Kosovo, reports began circulating of an unusually high incidence of leukemia among NATO troops from Italy, Belgium, Spain and Portugal. Twenty-two cases of leukemia were reported to have occurred from a pool of approximately 45,000 soldiers (Takata). According to the Mandelli Commission set up by the Italian Ministry of Defense, among Italian soldiers stationed in the Balkans, 12 cases of Hodgkin's lymphoma were observed while the expected rate, based on the Italian tumor registries, was 5.08 cases (*Il Messaggero*, CNN Italia, June 14, 2002). A typical response to this news from the defenders of DU weaponry was that DU could not possibly have been the cause because the "dose" was too low and the incubation period was too short. This follows logically from the ICRP model of radiation effects. But perhaps, defying ICRP thinking, DU may still have been involved by tripping predisposed cells into the onset of the disease or by promoting subclinical cases of leukemia to an open expression of the disease. Rosalie Bertell has this to say on the topic:

> Professor Gatti participated in the investigation, after the war in the Balkans, sponsored by UNEP (The United Nations Environment Program). The diseased tissues of soldiers and civilians affected by the war in the Balkans were submitted to Dr. Gatti for analysis. The soldiers, who served in the former Yugoslavian Territory, had an unusually high incidence of Hodgkin's and non-Hodgkin's lymphomas. The civilians, and staffs of the Humanitarian Missions, were suffering from the same diseases. Moreover, the Head of the Pediatric Clinic of Sarajevo, Professor Edo Hasanbegovich, reported an increase of leukemia among children, especially in towns located close

> to the Croatian border.
>
> Although many strict followers of the ICRP methodology protested that there was not sufficient latency period for these cancers to be radiation-related, they failed to consider the classic paper on the formation of clonal tumors by Peter C. Nowell. Radiation can initiate cancers, and also promote cancers which are hereditary or have been initiated by some other carcinogen. Promotion of cancers already initiated requires no latency period (Nowell). This exposition has been strengthened recently through the research into the many stages of cancer development, and genome instability of these various stages after exposure to low doses of ionizing radiation (Bertell, April 24, 2005).

In a different article, Bertell offers this observation: "Note also that early cancers, which have at times been attributed to DU, are most likely secondary to the immunological effect. A depressed immune system often changes the status of a subclinical cancer, with which the individual is coping, into a clinically diagnosable cancer" (Bertell, 2006). These reflections by Bertell add further credence to the claim that the ICRP model obstructs understanding of radiation's effects. The work of the ICRP has put blinders on the knowledge base, preventing accurate understanding of the impact to public health from the dispersal of depleted uranium amidst populations.

Epidemiological studies provide evidence that uranium contamination of the environment may adversely target DNA. According to Coryell and Stearns:

> In 1972, a study of cancer mortality found increases in prostate, pancreas, stomach, and colon cancer in men living on uranium mine tailings in Colorado relative to nearby populations not exposed to tailings; however, no increases in lung cancers or leukemia were found, suggesting radiation exposure was not the cause (Mason *et al.*). More recently, significant increases in gastric cancer were reported for counties in New Mexico with high deposits of uranium and uranium tailings (Wilkinson). A weak link between birth defects, stillbirths, and adverse outcomes of pregnancy was suggested for Navajo women living near uranium mine tailings (Shields *et al.*). A study of people exposed to tailings in Texas found a weak increase in chromosomal aberrations in lymphocytes of the exposed group relative to an unexposed group, and a significant increase in aberrations after lymphocyte challenge with gamma rays, indicating impaired DNA repair (Au *et al.*). These studies imply that environmental exposure to uranium could target DNA or DNA repair pathways (Coryell and Stearns).

The contention that the "dose" of radiation delivered by depleted uranium is too low to warrant concern is not supported by the scientific evidence. This is amply demonstrated in an *in vitro* study published under the title "Mutagenic Effects of a Single and an Exact Number of Alpha Particles in Mammalian Cells" (Hei *et al.*). Using a microbeam source, the researchers fired alpha particles at human-hamster hybrid cells. The nucleus of the target cells were hit by either a single or an exact number of alpha particles — two, four or eight. The linear energy transfer of the particles was 90 keV/μm, consistent with the energy spectrum of domestic radon exposure. For cells traversed by a single alpha particle, cell survival was high, about 0.82. However, the single alpha particles were highly mutagenic, inducing 110 mutations per 10,000 surviving cells. Further, cytotoxicity and the induction of mutations were dose-dependent, with the proportion of mutants with multilocus deletions increasing with the number of particle traversals. The authors offered the following conclusion: "These data provide direct evidence that a single alpha particle traversing a nucleus will have a high probability of resulting in a mutation and highlight the need for radiation protection at low doses."

The hazard of a single alpha particle was also noted in "Unexpected Sensitivity to the Induction of Mutations by Very Low Doses of Alpha-Particle Radiation: Evidence for a Bystander Effect" (Nagasawa and Little 1999). In this study, Chinese hamster ovary cells were exposed to a fluence of alpha particles from a plutonium-238 source. The dose-response relationship was linear over the dosage range of 5 cGy to 1.2 Gy. However, below the dose of 5 cGy, where the mean number of alpha-particle traversals per nucleus was significantly less than one (0.05–0.3), there was noted an unexpected sensitivity leading to a higher-than-expected frequency of mutations. The authors offered this conclusion: "The frequency of mutations induced by a single alpha particle traversing the nucleus of a cell was increased nearly five-fold at the lowest fluence studied. The data are consistent with the conclusion that the enhanced efficiency of each nuclear traversal at low particle fluences is the result of mutations arising in non-irradiated, bystander cells."

Often, differences in cell sensitivity are overlooked when blanket statements about the hazards posed by alpha particles are made. For instance, according to Durakovic: "The alpha particles may present a considerable genetic or carcinogenic risk when incorporated in the vicinity of non-differentiated, highly radiosensitive cells, such as the pluripotent stem cell" (Durakovic 1999). In "Undiagnosed Illnesses and Radioactive Warfare," Durakovic makes this observation:

> Radiation-induced cell death, chromosomal alterations, cellular transformation, mutations, and carcinogenesis are mainly the consequences of radiation deposited in the nucleus of the cell. Low-level

> radiation could induce genomic instability with no obvious dose rate effects, rendering high-dose extrapolation impossible and emphasizing the importance of the bystander effects in low-level alpha particle irradiation (Busby 2000; Morgan 2002). Alpha-induced sister chromatic exchanges at variable doses may elicit changes in the nucleus expressed as a gene mutation, while interacting with cellular cytoplasm (Lehnert *et al.*). These harmful effects challenge the criticism that low dosages of DU are incapable of producing genetic alterations (RC Miller *et al.*, Nagasawa and Little).

As demonstrated in the previous section, depleted uranium has been proven to induce genomic instability. According to Morgan *et al.* (1996): "The loss of stability of the genome is becoming accepted as one of the most important aspects of carcinogenesis, and the numerous genetic changes associated with the cancer cell implicate genomic stability as contributing to the neoplastic phenotype." In "Radiation-Induced Genomic Instability and Its Implications for Radiation Carcinogenesis," Huang, Snyder and Morgan state the following:

> Radiation-induced genomic instability is characterized by an increased rate of genetic alterations including cytogenetic rearrangements, mutations, gene amplifications, transformation and cell death in the progeny of irradiated cells multiple generations after the initial insult. Chromosomal rearrangements are the best-characterized endpoint of radiation-induced genomic instability, and many of the rearrangements described are similar to those found in human cancers. Chromosome breakage syndromes are defined by chromosome instability, and individuals with these diseases are cancer prone. Consequently, chromosomal instability as a phenotype may underlie some fraction of those changes leading to cancer.

According to Makhijani and Smith (2004): "Ionizing radiation is an accepted causative risk factor for all but one form of cancer [lymphocytic leukemia]." Thus, exposure to DU's radioactivity increases an individual's risk for developing cancer. The radiation emitted by DU, however, is not its only means for inducing mutations and promoting carcinogenesis. Like many other heavy metals, uranium can produce oxidative damage to DNA. Thus, DU's radiotoxicity and chemical toxicity work together in assaulting the integrity of an individual's genome. Again, Makhijani and Smith:

> Miller and colleagues have also found that tiny amounts of DU, too small to be toxic and only mildly radioactive, cause more cytogenetic damage in cells than either the toxicity or radiation alone could

> explain. Their latest results (Miller *et al.* 2000) corroborate a tentative report by the Royal Society, which suggests that the toxicity and radioactivity of DU reinforce one another in an unknown way, to the extent that more than eight times as many cells suffer cytogenetic damage than predicted. Thus the carcinogenic and genotoxic health risk of DU could be grossly underestimated by current theories.

Alexandra Miller and her colleagues have published the results of a number of *in vitro* and *in vivo* studies demonstrating the mutagenic capacity of depleted uranium. In 1996, they published "Oncogenes as Biomarkers for Low Dose Radiation-Induced Delayed Health Effects." As part of this study, muscle tissues obtained from rodents implanted with DU pellets exhibited activation of different oncogenes. Further, in kidney tissue implanted with DU pellets, there was a dose-dependent relationship between the level of oncogene expression increase and the number of pellets implanted. The authors concluded that "oncogenes may be effective biomarkers for low-dose radiation-induced carcinogenesis. A follow-up study was published the following year under the name "Biomarkers for Carcinogenesis: Oncogenic Activation by Depleted Uranium *In Vivo*" (see Durakovic 1999). This research focused on the expression of oncogenes in rats implanted with pellets of DU. During the course of this experiment, uranium dissolving from the pellets became widely distributed throughout the bodies of the test animals. Over a period of six months, as much as a 1000-fold increase in uranium levels was measured. The activation of oncogenes was observed as being DU dose- and time-dependent. At the rather low dose of 0.13 Gy, DU induced a transformation in cells to the tumorigenic phenotype. This discovery implied that, in addition to DU's radiotoxic properties, its chemotoxic properties were involved in inducing cellular oncogene expression. The activation of oncogenes in the presence of DU suggested that DU could potentially play a role in the initiation of malignant disease in humans (Durakovic, 1999).

Miller's lab conducted other rodent studies in an exploration of pinpointing DU radiation-induced biomarkers for assessing the risk of carcinogenesis. In 1998, they published "Oncogenes as Predictive Biomarkers for Low Dose Radiation Carcinogenesis: Potential Application for Risk Assessment." In this study, rodents were irradiated either with low-dose gamma or proton radiation or implanted with pellets of depleted uranium. The animals were euthanized at various times after irradiation, and their tissues were analyzed. Analysis of RNA demonstrated that radiation exposure induced preneoplastic oncogenic alterations that were dependent on time and radiation quality. This study confirmed that the genesis of oncogenes by radiation could be exploited to serve as early diagnostic molecular biomarkers for assessing the risk of carcinogenesis.

In the same year, Miller's team at the Armed Forces Radiobiology Research Institute published "Urinary and Serum Mutagenicity Studies with Rats Implanted with Depleted Uranium or Tantalum Pellets." This study was conducted to assess the potential mutagenic effects of long-term exposure to internalized DU while simultaneously studying the feasibility of defining biomarkers within urine to detect internal uranium exposure. A "significant enhancement of urinary mutagenicity" was observed in strains of bacteria. This signified exposure to a genotoxic agent. This urine mutagenicity increased in a dose- and time-dependent manner and demonstrated a strong positive correlation with uranium levels in urine. The authors concluded: "The results suggest that uranium content in the urine is correlated with urine mutagenicity and that urinary mutagenicity might be used as a biomarker to detect exposure to internalized uranium."

Also in 1998, Miller and associates published a landmark study entitled "Transformation of Human Osteoblast Cells to the Tumorigenic Phenotype by Depleted Uranium-Uranyl Chloride." This research was the first to report that a depleted uranium compound *in vitro* could transform human osteoblast cells to cells exhibiting characteristics of those which cause and/or produce tumors. According to the authors:

> DU-uranyl chloride-transformants are characterized by anchorage-independent growth, tumor formation in nude mice, expression of high levels of the k-ras oncogene, reduced production of the Rb tumor-suppressor protein, and elevated levels of sister chromatid exchanges per cell. DU-uranyl chloride treatment resulted in a 9.6 (+/- 2.8)-fold increase in transformation frequency compared to untreated cells. In comparison, nickel sulfate resulted in a 7.1 (+/- 2.1)-fold increase in transformation frequency. This is the first report showing that a DU compound caused human cell transformation to the neoplastic phenotype. Although additional studies are needed to determine if protracted DU exposure produces tumors *in vivo*, the implication from these *in vitro* results is that the risk of cancer induction from internalized DU exposure may be comparable to other biologically reactive and carcinogenic heavy-metal compounds (e.g., nickel).

Regarding the results of this research and subsequent follow-up studies, Miller and her team offered this observation:

> DU, unlike natural uranium, which is considered to be both a radiological and a chemical (heavy metal) hazard is not believed to be a significant radiation hazard because of its low specific activity. Studies

> with DU in our laboratory demonstrated neoplastic transformation of human cells under conditions in which ~14% of the DU-exposed cells were transformed but with less than 5% of the DU-exposed cells actually being traversed by an alpha particle. While these findings might suggest that the chemical component of DU could be primarily responsible for the transforming effects, recent cellular transformation and cytogenic findings from our laboratory have shown that alpha particles are involved in the neoplastic transformation process. Furthermore, the involvement of 'bystander effects' cannot be ruled out. Bystander effects, whereby cells that are not directly exposed to radiation exhibit adverse biological effects, have been observed in a number of experimental systems. Using uranium isotopes with differing specific activity, our laboratory has provided the first evidence that alpha particle radiation is involved in DU-induced effects, although chemical effects cannot be ruled out (Miller *et al.* 2002c)

Having determined that depleted uranium could induce neoplastic transformation in human osteoblast cells to the tumorigenic phenotype, the AFRRI followed up with an investigation as to whether or not nonradioactive heavy metal-tungsten alloys (HMTAs) could produce the same effects. These useful military alloys are composed of a mixture of tungsten (91-93%), nickel (3-5%), and either cobalt (2-4%) or iron (2-4%) particles. Following similar experimental protocols to the previous study of DU, this research revealed that HMTAs likewise were able to transform immortalized human osteoblast cells to the tumorigenic phenotype. The mechanism for this transformation was postulated as resulting from direct damage to the genetic material, "manifested as increased DNA breakage or chromosomal aberrations (Miller *et al.* 2001a). The discoveries of this line of research was summarized in an article published in *Military Medicine* (Miller *et al.* 2002a):

> Using a human osteosarcoma cell model, we demonstrated that soluble and insoluble DU compounds can transform cells to the tumorigenic phenotype, as characterized by morphological, biochemical, and oncogenic changes consistent with tumor cell behavior. Tungsten alloys and nickel were also shown to be neoplastic transforming agents, although at a frequency less than that of DU. Sister chromatid exchange, micronuclei, and alkaline filter elution assays showed DU and tungsten alloys were genotoxic. Exposure to a nontoxic, non-transforming dose of DU induced a small but statistically significant increase in the number of dicentrics formed in cells. These results suggest that long-term exposure to DU or tungsten alloys could be critical to the development of neoplastic disease in humans and that additional studies are needed.

In 2005, Miller and her research team published "Leukemic Transformation of Hematopoietic Cells in Mice Internally Exposed to Depleted Uranium." This article reported on the development of an *in vivo* model for leukemogenesis. Initially, test mice were implanted with pellets of depleted uranium, grouped by high dose and low dose, and the rodents serving as controls did not receive DU implantation. With the passage of time, the animals were injected with hematopoietic cells. Seventy-six percent of the high dose DU-implanted mice subsequently developed myeloid leukemia while only 16% developed the disease among the controls. The low-dose group did not show significant increase in leukemia development. The authors offered the following observation:

> This was the first report describing the consistent development of leukemic transformation of FDC-P1 cells when injected intravenously into DU implanted male mice. Karyotypic analysis confirmed that the leukemic cells had originated from the injected cells. Ongoing studies on the growth properties of the leukemic cells in vitro and in vivo are underway to confirm that the FDC-P1 cells had specifically undergone malignant transformation. We additionally speculate that the DU-altered host environment played a significant role in inducing leukemic transformation. Studies are being conducted to determine if alterations in the immune system are associated with exposure to the DU and if these alterations are involved in the development of leukemia. The extent of the role that alpha radiation plays in the leukemogenesis induced by DU is still, however, not fully known nor is the impact of these findings on the development of leukemia in DU-exposed humans (Miller *et al.* 2005a).

A follow-up study was also published in 2005 under the title "Depleted Uranium Internal Contamination: Carcinogenesis and Leukemogenesis *in Vivo*." This article reported on three *in vivo* mouse models for mutagenesis and carcinogenesis. The leukemogenesis model mentioned above was discussed. In addition, research was discussed of genetically developed mice carrying the LacI gene in cells of all of their tissues. Internalized DU in these rodents resulted in a significant increase in the mutagenic frequency in the LacI gene in the testes of exposed male mice. In further confirmation of the carcinogenic potential of DU, mice deficient in the tumor suppressor gene p53 were implanted with DU. Seventy-five percent of the test animals in this study developed carcinoma of the bladder within 90 days of the initial DU exposure. According to the authors: "These results suggest that long-term exposure to internalized DU could be critical to the development of neoplastic disease in humans and additional studies are needed" (2005c).

The results of these studies are intriguing and hint at a potentially significant factor

in DU-induced disease in humans. Depleted uranium apparently alters the internal environment of the organism. These undefined alterations have demonstrated the capacity to promote expression and/or transformation of precursor or suppressor genes leading to various types of cancer. Thus, DU's effect on individuals may vary depending on their unique genetic make-up, promoting genetic predispositions to a variety of disease endpoints.

The mutagenic potential of DU has been studied by other research teams. Karaczyn *et al.* published "Depleted Uranium - Induced Malignant Transformation in Human Lung Epithelial Cells." This *in vitro* research demonstrated that DU had the potential of transforming immortalized human bronchial epithelial cells, altering oncogenes in a manner characteristic for the malignant phenotype. Yang *et al.* demonstrated that DU was carcinogenic *in vitro* in "Malignant Transformation of Human Bronchial Epithelial Cells (BEAS-2B) Induced by Depleted Uranium." In 2002, Hahn and associates published "Implanted Depleted Uranium Fragments Cause Soft Tissue Sarcomas in the Muscles of Rats." This study demonstrated that DU metal fragments of sufficient size can induce the growth of tumors in immediate proximity to the fragments.

A preliminary human study was published by Papathanasios and colleagues under the title of "Effect of Depleted Uranium Weapons Used in the Balkan War on the Incidence of Cervical Intraepithelial Neoplasia (CIN) and Invasive Cancer of the Cervix in Greece." The purpose of this study was to compare the rates of CIN and invasive cancer of the cervix in two district areas in Greece near the border of the former Yugoslavia with the rates of these diseases in an urban area of Greece away from the border. Disease incidence in the three years before and after the war in Yugoslavia were gathered from hospital records and compared. For the period 1997 to 1999, the incidence of CIN at the hospitals in Kilkis and Serres was 0.68% and 0.9%. Between 2000 and 2002, these figures rose to 1.11% and 1.13% respectively. In comparison, the incidence of CIN between 1997 and 1999 reported from Hippokrateion University Hospital of Thessaloniki was 1.06%. This rate fell to 0.88% for the three-year period 2000 to 2002. According to the authors:

> There has been a small but not statistically significant increase in the incidence rates of CIN in the two district areas near the borders with the former Yugoslavia over the last few years ($p = 0.355$ for Kilkis and $p = 0.472$ for Serres), compared with the small but statistically significant decrease in the incidence of CIN in the urban area of Thessaloniki ($p = 0.0275$). The rates of invasive cancer of the cervix diagnosed from the routine smear tests were too small to make any conclusions. CONCLUSION: The increase in the incidence of precancerous lesions of the cervix in areas near the borders with the former Yugoslavia during the last three years may be influenced by

> environmental factors such as exposure to depleted uranium due to the bombings of 1999. To confirm this bigger epidemiological studies are needed.

Other evidence exists that depleted uranium is carcinogenic. At the World Uranium Weapons Conference held in Hamburg in 2003, Professor Alim Yacoub made a presentation entitled "The Evidence For Causal Association Between Exposure To Depleted Uranium And Malignancies Among Children In Basrah By Applying Epidemiological Criteria Of Causality." The data presented was gathered from the Women and Children's Hospital of Basra which serves the whole region of Basra. All children under the age of 15 with malignancies or suspected malignancies are sent to this one institution for medical evaluation. In addition, all pregnant women are brought to this hospital for delivery. If any children are born with malformations, they are assessed by the same neonatologist. All cases are recorded. From this database and census data for Basra, incidence rates were calculated. According to Professor Yacoub's lecture, an alarming trend in malignant diseases has surfaced since the first Gulf War. In 1990, the rate of malignant diseases among children under 15 years of age was 3.98/100,000. By 1995, that rate had nearly doubled to 7.8/100,000. In 1999, the rate had jumped to 10.7/100,000. In 2000, the rate stood at 13.1/100,000. Throughout the decade, increases were observed in the frequency of leukemia, lymphoma, brain tumors, Wilms tumor [kidney] and neuroblastoma.

Depleted Uranium is Cytotoxic

Uranium has been proven to disrupt the normal functioning of cells. In 1948, it was demonstrated by Barron *et al.* that uranium can have a deleterious effect on cellular respiration. Uranium has a tendency to be incorporated into cell membranes and its presence makes the membrane more impermeable to glucose. In summing up their research, the authors made this observation:

> These experiments favor the assumption that U combines with the protein portion of the cell membrane and thus renders it less or completely impermeable to the passage of certain oxidizable substrates. This remarkable property of uranium of inhibiting cellular metabolism not by combination with enzymes but by combination with the cell membrane and alteration of its permeability is, we believe, the first example of a new kind of oxidation inhibition, surface inhibitions.

Uranium is also known to interfere with cellular carbohydrate metabolism. Hodge, Maynard and Downs offered this observation in 1951:

> The uranous ion produces a toxic effect on the living cells by inhibiting the processes of metabolism of carbohydrates by the inhibition enzyme systems, particularly hexakinase at the sites of ATP surface-building through magnesium-hexokinase mechanism. The adsorption process results in the sixth glucose carbon atom interacting with a phosphate atom of ATP, with negatively charged glucose-6-phosphate re-entry inhibition through a negatively charged point of entry at the cell surface. A uranyl ion replacing a magnesium ion binds the ATP molecule to hexokinase. ATP-uranyl-hexokinase complex blocks the release of phosphate to glucose, inhibiting its first step of metabolic utilization with non-metabolized glucose in the extracellular environment

In 2007, Sandra Wise and her associates at the University of Southern Maine published a groundbreaking study that should sound the death knell for DU weapons. In "Particulate Depleted Uranium is Cytotoxic and Clastogenic to Human Lung Cells," the researchers announced evidence that **insoluble particles of uranium produce different biological effects from soluble uranium**. In particular, they discovered that insoluble particles of UO_3 are clastogenic (having the ability to alter the structure of chromosomes) while soluble UA (uranyl acetate) produces no such effect. In this study, cultures of WTHBF-6 cells, a clonal cell line derived from normal human bronchial fibroblasts, were exposed to either UO_3 or UA for 24, 48 and 72 hours. After exposure, the colonies were allowed to grow for 10 days. Analysis of the colonies revealed that **both uranyl acetate and uranium trioxide induced time- and concentration-dependent cytotoxicity but the UO_3 produced clastogenicity in a time- and concentration-dependent manner while the soluble DU did not, even after chronic exposure.** According to the authors: "These data suggest that exposure to particulate DU may pose a significant genotoxic risk and could possibly result in lung cancer." In the conclusion to their article, the authors offered the following observations:

> **Our data show that particulate DU is clastogenic, whereas soluble DU is not. The explanation for this is uncertain, but one possible explanation is that there is a difference in uptake mechanisms. That is, DU particles can enter the cell and intracellularly dissolve by phagocytosis, whereas soluble DU cannot. This mechanism has previously been elucidated for nickel to explain the differences between its soluble and particulate compounds** [emphasis added] (Costa).

> The WTHBF-6 cells used in our study are known to internalize metal particles by phagocytosis (Xie *et al.*), and thus, this mechanism certainly is biologically possible in this model system. An alternative mechanism, observed for particulate chromate compounds, is that the DU particles provide chronic exposure to soluble DU with continuous occurrence of extracellular dissolution (Xie *et al.*). We feel this is unlikely because chronic exposure to soluble DU was unable to cause an increase in clastogenicity.
>
> For soluble DU, we found that cytotoxicity was concentration-dependent, whereas clastogenicity was not. These data indicate that cell death was not likely caused by chromosomal abnormalities. The cytotoxic mechanism is uncertain, but one non-genotoxic possibility is that DU may directly target the mitochondria, leading to apoptosis. This possibility is consistent with a previous *in vitro* study of rabbit proximal tubule cells which showed that concentrations of soluble uranyl nitrate of 1 mM or greater cause mitochondrial damage (Brady *et al.*).
>
> Epidemiological studies have had a difficult time ascertaining the lung cancer risk posed by DU. Our data suggest that in human lung cells, significant clastogenicity is only observed at highly cytotoxic concentrations. Thus, many of the damaged cells will be removed by cell death, and thus if DU is carcinogenic in human lung cells, it may require a high dose or involve a non-genotoxic mechanism. Other metals such as lead have been proposed to have significant non-genotoxic effects such as DNA repair inhibition or alterations in DNA conformation (Zelikoff *et al.*).

The pernicious effect of uranium on healthy cell function has been further elucidated by other research initiatives. The article "A Search for Cellular and Molecular Mechanisms Involved in Depleted Uranium (DU) Toxicity" (Pourahmad *et al.*) demonstrated that DU is toxic to cells via the initiation of oxidative stress. Uranyl acetate introduced into isolated rat hepatocytes rapidly produced glutathione oxidation, reactive oxygen species (ROS) formation, lipid peroxidation, decreased mitochondrial membrane potential and lysosome membrane rupture. This cytotoxic process was countered by ROS scavengers, antioxidants and glutamine (ATP generator). The authors pinpointed the mitochondria and lysosomes as vulnerable cellular targets to oxidative stress induced by uranyl acetate. Similar findings were reported in an article entitled "Assessment of the Pro-Oxidant Activity of Uranium in Kidney and Testis of Rats." In this study, the test animals were given uranyl acetate dihydrate in their drinking water. Subsequent analysis of kidneys and testes revealed evidence of a depletion in the antioxidant defense system. According

to the authors: "The results of this study suggest that graded doses of U elicit depletion of the antioxidant defense system of the rat and induce oxidative stress in testes and kidneys" (Linares *et al.*).

It is important to note that the presence of heavy metals within cells can disrupt the mechanisms which are set in motion by oxidative stress. This will weaken the built-in defenses of cells and permit cellular degradation. Rosalie Bertell has this to say on the topic:

> All cells contain an endogenous antioxidant in the water-soluble part of the cellular fluid, which normally deals with free radicals. This antioxidant, called glutathione (GSH), repairs most cellular structures that are damaged and oxidized by free radicals. It can also detoxify many electrophilic mutagenic threats to the cell. This antioxidant function of GSH is normally credited as having cancer-protective properties, since it neutralizes free radicals. Cellular repair mechanisms depend heavily on the presence of GSH in cells.
>
> Another function of GSH is to rid cells of toxic heavy metals. Heavy metals bind with the GSH and are carried out of the cell and to the gallbladder, for excretion in bile. This process is a mechanism for depleting the GSH, as well as for ridding the cells of heavy metals. Hence heavy metals, such as DU, deplete GSH at the time when it is most needed for its protective cell-repair and antioxidant work. Individuals may have more or less GSH by nature or through exposure history. Yet this is one of the main biochemicals needed for the repair mechanisms on which the physics methodology for calculating radiation dose-response depends for its applicability.
>
> Superoxide dismutase (SOD) is another chemical, an enzyme produced both by the liver and in the mitochondria of all cells, which acts as an anti-inflammatory and antioxidant. The body needs zinc, copper, and manganese to produce sufficient functional SOD. Toxic metals can replace the manganese, making the SOD dysfunctional, or the cell can merely run out of SOD because of overdemand for antioxidants in the mitochondria. This overdemand can also deplete the manganese needed for protective enzymes in the cell, leaving it open to viral or bacterial invasion. SOD also varies in abundance and can be damaged by a variety of chemicals. Mercury and arsenic are found in pesticides and fungicides, and in vaccines. Nickel is a component of steel, which can be vaporized in a DU metal fume. Nickel can deplete the body's zinc stores, compromising the SOD cellular

> immune system. These other metals also play parts in the breakdown of cellular functions. Thus heavy metal exposure causes oxidative stress that weakens the cellular repair mechanism, which would normally provide some protection against low-dose radiation exposure from DU (Bertell 2006).

Partial confirmation of Bertell's observations on the relationship between uranium-induced oxidative stress and cytotoxicity is provided by research published under the title of "Uranium Induces Oxidative Stress in Lung Epithelial Cells" (Periyakaruppan *et al.*). The authors summarize their study as follows:

> In the current study, uranium toxicity was evaluated in rat lung epithelial cells. The study shows uranium induces significant oxidative stress in rat lung epithelial cells followed by concomitant decrease in the antioxidant potential of the cells. Treatment with uranium to rat lung epithelial cells also decreased cell proliferation after 72 hours in culture. The decrease in cell proliferation was attributed to loss of total glutathione and superoxide dismutase in the presence of uranium. Thus the results indicate the ineffectiveness of antioxidant system's response to the oxidative stress induced by uranium in the cells.

!!!

We interrupt this discussion with an important message! Read the last paragraph again and then look for an expanded discussion on oxidative stress in the "definitive" works on uranium toxicity. Search the *Toxicological Profile for Uranium* by the Agency for Toxic Substances and Disease Registry. Search the Royal Society's *The Health Hazards of Depleted Uranium Munitions*. Search the World Health Organization's *Depleted Uranium: Sources, Exposures and Health Effects*. Search the Rand Report, *A Review of the Scientific Literature as it Pertains to Gulf War Illness*. What do your searches reveal? **NOTHING! ZIP! NADA!** Outside of a passing reference to the subject, these works are mute on the subject. But how can this be? Scientific evidence exists that internalized uranium produces oxidative stress. When uranium decays, it produces free radicals. As a heavy metal, uranium produces free radicals. Nanoparticles produce free radicals. Married to these realities is the fact that oxidative stress is known to be genotoxic, mutagenic and cytotoxic. Further, oxidative stress is known to erode healthy cellular structure and contribute to the etiology of a number of neurological and degenerative diseases. It is quite feasible that oxidative stress in people chronically contaminated with uranium is a factor in the nonspecific disease process known as Gulf War Syndrome. And yet, those who control the discussion as to the health effects

of DU don't even deem the subject worthy of consideration.

Returning to the subject at hand, uranium has been shown to be toxic to specialized cell lines. The vulnerability of macrophages to uranium exposure was revealed in "Depleted Uranium-Uranyl Chloride Induces Apoptosis in Mouse J774 Macrophages" (Kalinich *et al.*) Those participating in this study discovered that uranium uptake by macrophages increased in a time-dependent manner. Treatment with 1, 10 and 100 microM of depleted uranium-uranyl chloride resulted in decreased viability of the macrophages within 24 hours. Changes in the membrane structure was indicative of the apoptotic process. Those cells receiving the highest doses manifested signs of alteration within two hours of exposure. Events associated with apoptosis were noted at all doses and included morphological changes to the macrophages and DNA fragmentation. According to the authors: "These results suggest that the uptake and concentration of soluble depleted uranium by macrophages initiates events that result in the apoptotic death of these cells."

The implications of this study are particularly disturbing. In response to the inhalation of uranium, macrophages are mobilized to clear the lungs of the contaminant. However, the toxicity of the uranium metal ion kills these cells, and consequently, prevents clearance. The contaminant is then awarded the opportunity to make further inroads into the body's interior. This is a clear example of uranium's capacity to disrupt normal immune function. Confirmation for this was reported in the article "Cytotoxic Effect of Uranium Dioxide on Rat Alveolar Macrophages" (Tasat and de Rey). In this study, macrophages obtained from the lungs of rats were exposed to increasing concentrations of particulate UO_2. Uranium effects were assessed by analyzing cell viability and phagocytosis of particles which averaged 0.6 microns in diameter. The number of macrophages which devoured particles of uranium reached a maximum after six hours. The average time for these cells to become nonviable was 16 hours. After this period of time, dead cells predominated. The researchers observed that immediately after phagocytosis, the particles of uranium were present in the phagocytic vacuoles of the macrophages. With the passage of time, they noted that the particles were outside the vacuoles which resulted from membrane damage. The outcome of this study was clearly summarized by the authors:

> This study reveals the ability of alveolar macrophages to phagocytize uranium particles despite the high toxicity the metal exerts on cell membranes. However, lethal effects soon become evident. Ultrastructural analysis showed uranium particles confined within membrane-bound vacuoles or free in the cytoplasm. Marked ultrastructural alterations consistent with cell death were frequently observed. The elimination of the first biological barrier hinders the

> scavenging of particulate contaminants in alveolar spaces, thus favoring the translocation to target organs.

Other studies have shed further light on DU's possible effect on immune response. In one study, researchers set out to investigate the toxic effects of environmental DU on the immune system (Wan *et al.*). They examined the influences of DU (in the form of uranyl nitrate) on viability and immune function, as well as cytokine gene expression, in rodent peritoneal macrophages and splenic CD4+ T cells. Both cell types were exposed to various concentrations of DU, and cell death via apoptosis and necrosis was analyzed. The authors reported these findings:

> DU cytotoxicity in both cell types was concentration dependent, with macrophage apoptosis and necrosis occurring within 24 hr at 100 microM DU exposure, whereas CD4+ T cells underwent cell death at 500 microM DU exposure. Noncytotoxic concentrations for macrophages and CD4+ T cells were determined as 50 and 100 microM, respectively. Lymphoproliferation analysis indicated that macrophage accessory cell function was altered with 200 microM DU after exposure times as short as 2 hr. Microarray and real-time reverse-transcriptase polymerase chain reaction analyses revealed that DU alters gene expression patterns in both cell types. The most differentially expressed genes were related to signal transduction, such as c-jun, NF- kappa Bp65, neurotrophic factors (e.g., Mdk), chemokine and chemokine receptors (e.g., TECK/CCL25), and interleukins such as IL-10 and IL-5, indicating a possible involvement of DU in cancer development, autoimmune diseases, and T helper 2 polarization of T cells. The results are a first step in identifying molecular targets for the toxicity of DU and the elucidation of the molecular mechanisms for the immune modulation ability of DU.

Included within the text of this article are these interesting observations:

> It was hypothesized that Gulf War syndrome may be explained as a systemic shift in cytokine balance from a T helper (Th) 1 profile toward a Th2 profile because the syndrome is clinically similar to autoimmune diseases (Rook and Zumla 1997; Skowera *et al.* 2004). In this study we hypothesized that DU exposure may compromise the immune system function by inducing immune cell apoptosis and modulating immune cell cytokine gene expression, which may be predictive of DU immunotoxicity. This hypothesis is consistent with the findings of Li *et al.* (2001), Pallardy *et al.* (1999), and Rodenburg *et al.*

> (2000), which showed that cell death through apoptosis or necrosis may cause serious adverse effects such as immunosuppression or lead to an altered immune response.

Other studies have investigated the cytotoxicity of depleted uranium. As reported in "Cytogenetic Toxicity of Uranyl Nitrate in Chinese Hamster Ovary Cells," Lin and colleagues performed an *in vitro* investigation of the cellular response to uranium exposure. They observed lower cell viability, depressed cell cycle kinetics, and increased sister chromatid exchanges, micronuclei, and chromosomal aberrations. Another interesting study was published under the name "Transcriptomic and Proteomic Responses of Human Renal HEK293 Cells to Uranium Toxicty." This investigation conducted by Prat *et al.* investigated the cellular response of certain genes and proteins to uranium exposure. Commenting on their work, the authors stated: "We particularly show that 25% of modulated genes concern signal transduction and trafficking, that the calcium pathway is heavily disturbed and that nephroblastomas-related genes are involved (WIT-1, STMN1, and STMN2). A set of 18 genes was deregulated whatever the concentration of toxicant, which could constitute a signature of uranium exposure."

One final study deserves mention. Although not a study on depleted uranium, further investigation may someday link its results to uranium exposure. In 2002, Compston and her associates published a study entitled "Reduced Bone Formation in UK Gulf War Veterans: A Bone Histomorphometric Study." This study was important because it delivered objective information on the health status of 17 veterans who, with one exception, were expressing musculoskeletal symptoms of so-called Gulf War Illness. Further, it lent support to the established fact that Gulf War veterans suffered proportionately more hospitalizations for certain specific diagnoses which included fractures and other bone and soft tissue injuries (Gray *et al.*). In the course of the investigation, bone biopsies of the iliac crest were performed and analyzed, while bone mineral density of the upper femur and lumbar spine was measured. In an editorial in the *Journal of Clinical Pathology*, the results of this study were concisely elucidated:

> Very briefly, they showed that although the bone biopsies showed "considerable heterogeneity" across the 17 Gulf War veterans there was a significant ($p = 0.027$) reduction in the amount of cancellous (trabecular) bone and a decrease in osteoblast activity and therefore bone formation ($p < 0.0001$). Although osteoclast numbers were reduced, the extent of bone surfaces showing evidence of erosion was increased. Because eroded surfaces remain visible until they are filled in by osteoid deposited by osteoblasts, this apparent anomaly can be explained on the basis of failure of osteoblasts to cover over eroded

surfaces, rather than an absolute increase in osteoclasis (Freemont).

The Compston study provides hard evidence that service in the Gulf produced in the test subjects a specific disorder involving bone-cell dysfunction and subsequent bone loss. As Compston *et al.* state: "These results demonstrate that in this group of Gulf War veterans there was a significant reduction in bone formation at both the cellular and tissue level and this was associated with a reduction in cancellous bone area." Whether or not there is any association of this disorder with exposure to depleted uranium is unknown. However, there is supporting evidence that DU may be a factor. First of all, the skeleton is the largest repository of internalized uranium. Second, research has provided evidence that uranium can induce morphological and metabolic changes in osteoblasts. This finding was published in 2006 by Tasat *et al.* under the title "Ultrastructural and Metabolic Changes in Osteoblasts Exposed to Uranyl Nitrate." Using electron microscopy, the researchers observed that "the ultrastructure of active and inactive osteoblasts exposed to uranium presented cytoplasmic and nuclear alterations." In addition, they analyzed cell proliferation, generation of reactive oxygen species (ROS), apoptosis, and alkaline phosphatase (APh) activity in osteoblasts exposed to various concentrations of uranyl nitrate. Neither the cell proliferation ratio nor the rate of apoptosis were modified by the test doses. However, ROS generation increased in a dose-dependent manner in all tested doses. APh activity was observed to decrease in all cells treated with uranyl nitrate. The authors summarized their findings as follows: "Our results show that UN modifies osteoblast cell metabolism by increasing ROS generation and reducing APh activity, suggesting that ROS may play a more complex role in cell physiology than simply causing oxidative damage." Adding further weight to the theory that uranium has an adverse effect on bone was a 2006 study by Tissandie *et al.* published under the title "*In Vivo* Effects of Chronic Contamination With Depleted Uranium on Vitamin D (3) Metabolism in Rats." Vitamin D(3) is an essential factor in mineral and bone homeostasis, and this research revealed that DU disrupts vitamin D(3) metabolism. In DU-exposed rats, the active vitamin D plasma level was significantly decreased. Decreased levels of vitamin D target genes and gene regulators were also observed. In the brains of the test animals, lower levels of genes involved in vitamin D metabolism were also observed. Overall, the study verified that DU exposure could affect the mechanisms of calcium homeostasis.

Depleted Uranium is Teratogenic

Being genotoxic, cytotoxic and mutagenic, depleted uranium can disrupt normal fetal development. It has the capacity to induce mutations in the male and female germ

cells prior to conception, and it can adversely affect the developing embryo/fetus at any time between conception and birth. In experimental animals exposed to uranium compounds, uranium has been found to accumulate in the testes (ATSDR). Gulf War veterans wounded by DU shrapnel have elevated levels of uranium in their semen (Royal Society). In light of this discovery, the Royal Society cautions that this raises "the possibility of adverse effects on the sperm from either the alpha-particles emanating from DU, chemical effects of uranium on the genetic material or the chemical toxicity of uranium." Others have postulated that an enhanced hazard to the DNA in sperm cells is created due to synergistic effects between uranium's alpha emissions and its chemically induced oxidative stress (Arfsten *et al.*, Domingo 2001). In experiments on female rats, it was discovered that uranium crosses the placenta and concentrates in the tissue of the fetus (ATSDR, Royal Society, Albina *et al.* 2003). In experiments involving the implantation of DU pellets into pregnant female rats, it was observed that the amount of contamination to the mother was directly related to the amount of contamination in the placenta and in the fetus (Arfsten *et al.*; Domingo 2001).

One little-known effect of the Gulf War was the statistically significant increase in the incidence of birth defects among babies born to veterans. This conclusion came to light in an epidemiological study performed by Araneta and her associates and published under the title "Prevalence of Birth Defects Among Infants of Gulf War Veterans in Arkansas, Arizona, California, Georgia, Hawaii, and Iowa, 1989-1993." The researchers investigated the military records of 684,645 Gulf War veterans and 1,587,102 non-deployed veterans and the birth certificates of 2,314,908 babies born in states that conducted active case ascertainment of birth defects. From this information, they identified 11,961 infants born to Gulf War Veterans and 33,052 infants born to non-deployed veterans. This data further identified 450 infants born to mothers who had served in the Gulf War and 3966 infants born to non-deployed mothers. For infants conceived postwar to male veterans, a significantly higher prevalence of tricuspid valve insufficiency and aortic valve stenosis was discovered, compared to their non-deployed counterparts. Also, among Gulf War veterans, there was a higher incidence of aortic valve stenosis and renal agenesis [absent or imperfect development of the kidney] or renal hypoplasia [underdevelopment of the kidney] in infants born after service in the Gulf than among infants conceived prior to the war. In addition, this study confirmed that the incidence of hypospadias [an abnormal location of the opening of the urethra] was significantly higher among male infants conceived by female Gulf War veterans compared to male infants born to non-deployed women.

Under the best of circumstances, designing and successfully carrying out an epidemiological study on the variables affecting birth outcomes presents a rigorous challenge. To produce meaningful results in any impoverished country ravaged by war is probably

impossible. Limited access to health care, poor or nonexistent record keeping, travel restrictions, an impoverished standard of living, hunger, stress, the list goes on and on, all work together to camouflage trends in birth outcomes and the incidence of neonatal deaths and congenital malformations. A more suitably chaotic environment could not be envisioned for allowing an aggressor to escape accountability in unleashing weapons that target reproductive health.

In the absence of definitive epidemiological studies which might define the teratogenic capacity of DU, what alternative sources of information are available to provide insight into possible harm inflicted on developing embryos and fetuses in countries targeted with DU weapons? The answer to this question, as if completing a large circle, brings us back to the corrupted theory of radiation effects from internalized radioactive particles and the political propaganda this false science has spawned. According to publication No. 90 of the ICRP (2003), the threshold dose for radiation-induced teratogenic effects is **100 mSv**. And how was this number derived? You guessed it: from studies of the Japanese survivors of the atomic bombs dropped on Hiroshima and Nagasaki. And from amongst this population, the only increased risks to fetuses, exposed to the threshold dose or above, was mental retardation and reduced head size (Schmitz-Feuerhake). According to the Atomic Bomb Casualty Commission, there was no increase in the incidence of birth defects among children whose parents were exposed to the blasts (Nakamura). No genetic effects were ever detected among the offspring of survivors. Presently, no increased rates of mortality or cancer incidence in children born to exposed parents have yet been detected. (Nakamura).

As examined elsewhere in this book, this data simply cannot be trusted. Inge Schmitz-Feuerhake from the Department of Physics at the University of Bremen, Germany, has this to say on the topic:

> As was pointed out by different researchers, the Japanese data suffer, however, from several restrictions which limit their suitability as a general base for deriving radiation risks. One point is a probable and proven severe selection bias because of the catastrophic situation after the bombing. Another objection which must be stressed, especially considering perinatal effects, is the fact that the investigations of the Radiation Effects Research Foundation (RERF) in Hiroshima did not begin earlier than 5 years after the catastrophe when the RERF research institute was established there. The completeness of the data must therefore be put into question (Schmitz-Feuerhake).

If we suspend belief in the reliability of the Hiroshima data, what other body of

data exists that can provide knowledge of the teratogenic effects of radiation on populations? Chernobyl! Numerous studies conducted throughout Europe testify that radiation released into the environment produced a wide spectrum of developmental malformations at doses far below the threshold dose upheld by the ICRP. This explains one reason for the propaganda campaign pursued by the radiation protection agencies that attempts to dismiss the Chernobyl accident as either poorly researched or of little consequence.

Many hundreds of scientific papers have been published in Russia and throughout Europe on the catastrophic effects of Chernobyl on public health (ECRR 2006; IIRC). An excellent summary of this vast body of evidence was recently published by the European Committee on Radiation Risk under the title *Chernobyl: 20 Years On*. The essays within this volume, written by respected authorities in their field, represent a first attempt to compile the vast amount of data on the Chernobyl disaster that was originally published in languages other than English. Pertinent to the present discussion is the article "Radiation-induced Effects in Humans After *in utero* Exposure: Conclusions from Findings After the Chernobyl Accident." The author, Inge Schmitz-Feuerhake, provides an overview of dozens of studies which confirm that low levels of radiation present in many areas of Europe after Chernobyl were responsible for a wide variety of birth defects. The data from Chernobyl are dangerous. It bears witness that the conclusions drawn from the atomic bomb survivors is fallacious, fraudulent and felonious. Further, it demonstrates that levels of internal contamination deemed to be without consequence by the radiation protection agencies could be responsible for producing the types of birth defects reported in Iraq and Afghanistan.

What follows is a summary of teratogenic effects documented after Chernobyl with citations of where the research was published. This evidence, gathered by Schmitz-Feuerhake, demonstrates that plenty of scientific evidence exists of "nonmalignant" disorders produced by Chernobyl.

Observed increase of congenital malformations *in utero* after exposure by the Chernobyl accident:

Belarus National Genetic Monitoring Registry-
Anencephaly, spina bifida, cleft lip and/or palate, polydactyly, limb reduction defects, esophageal atresia, anorectal artesia, multiple malformation (Lazjuk *et al.* 1997)

Belarus highly exposed region of Gomel-
Congenital malformations (Bogdanovich 1997; Savchenko 1995)

Chechersky district of the Gomel region-
Congenital malformations (Kulakov *et al.* 1993)

Mogilev region-
Congenital malformations (Petrova *et al.* 1997)

Brest region-
Congenital malformations (Shidlovskii 1992)

Ukraine, Polessky district of the Kiev region-
Congenital malformations (Kulakov *et al.* 1993)

Lygyny region-
Congenital malformations (Godlevsky and Nasvit 1998)

Turkey-
Anencephaly, spina bifida (Akar *et al.* 1988/89; Calayan *et al.* 1990; Güvenc *et al.* 1993; Mocan *et al.* 1990)

Bulgaria, region of Pleven-
Malformations of heart and central nervous system, multiple malformations (Moumdjiev *et al.* 1992)

Croatia-
Malformations by autopsy of stillborns and cases of early death (Kruslin *et al*. 1998)

Germany, German Democratic Republic, Central Registry-
Cleft lip and/or palate (Zieglowski and Hemprich 1999)

Bavaria-
Cleft lip and/or palate, congenital malformations (Scherb and Weigelt 2004; Korblein 2003a, 2004; Scherb and Weigelt 2003)

West Berlin, Annual Health Report of 1987-
Malformations in stillborns (Strahlentelex 1989)

City of Jena, Registry of Congenital Malfomations-
Isolated malformation (Lotz *et al.* 1996)

Observed increase of stillbirths, infant deaths, spontaneous abortions and low birth weight after *in utero* exposure by the Chernobyl accident

Belarus, selected regions-
Perinatal deaths (Petrova *et al.* 1997)

Chechersky District near Gomel-
Perinatal deaths (Kulakov *et al.* 1993)

Gomel region-
Perinatal deaths (Korblein 2003a, 2003b)

Ukraine, Polessky District near Kiev-
Perinatal deaths, reduced birth rate, premature births (Kulakov *et al.* 1993)

Lygny region-
Early neonatal deaths (Godlevsky and Nasvit 1998)

Zhitomir oblast, Kiev region, Kiev City-
Perinatal deaths, reduced birth rate (Korblein 2003a, 2003b)

Europe: Greece, Hungary, Poland-
Stillbirths (Scherb *et al.* 1999b, 2000b, 2003)

Sweden-
Infant mortality (Korblein 2003a)

Poland-
Spontaneous abortions (Ulstein *et al.* 1990)

Norway-
Low birth weight (Czeisel 1988)

Hungary-
Premature births among malformed children (Harjulehto *et al.* 1989)

Finland-
Reduced birth rate (Harjulehto *et al.* 1991), Stillbirths (Scherb and Weigelt 2003)

Germany- Total FRG + GDR
Perinatal deaths (Korblein and Kuchenhoff 1997; Scherb *et al.* 2000a, 2003)

Southern Germany-
Early neonatal deaths (Lüning *et al.* 1989)

Bavaria-
Perinatal deaths, stillbirths (Grosche *et al.* 1997; Scherb *et al.* 1999a, 2000a, 2003)
Reduced birth rate (Korblein 2003a)

Increase of Down's syndrome after *in utero* exposure by the Chernobyl accident

Belarus, National Genetic Monitoring Registry-
Excess 1987-1994 ca. 17% (Lazjuk *et al.* 1997)

Western Europe-
Beginning one year after the accident, reaching 22% within 3 years (Dolk *et al*. 1999)

Sweden-
"Slight" excess in most exposed areas (30%) (Ericson and Kallen 1994)

Scotland, Lothian Region (0.74 million inhabitants)-
Excess peak in 1987 (2-fold significant) (Ramsay *et al.* 1991)

South Germany-
Investigations of amniotic fluid (Sperling *et al.* 1991)

Berlin West-
Sharp increase after 9 months (Sperling *et al.* 1991, 1994)

Observed health defects in children after *in utero* exposure by the Chernobyl accident apart from malformations and Down's syndrome

Belarus, Selected Regions-
Mental disorders (Kondrashenko *et al.* 1996)
Speech-language disorders, mental retardation (Kolominsky *et al.* 1999)

Chechersky District near Gomel-
Diseases of respiratory organs, blood, circulation, etc. (Kulakov *et al.* 1993)

Stolin District in Brest region-
Diseases of respiratory organs, glands, blood, circulation, digestive organs (Sychik and Stozharov 1999a, 1999b)

Belarus, Ukraine, Russia-
Mental retardation and other mental disorders (Kozlova *et al.* 1999)

Ukraine, Polessky District near Kiev-
Diseases of respiratory organs, blood, circulation etc. (Kulakov *et al.* 1993)

Ukraine, Rovno Province-
Childhood morbidity (Ponomarenko *et al.* 1993)

Immigrants to Israel from contaminated areas-
Asthma (Kordysh *et al.*, 1995)

The evidence of the teratogenic impact of Chernobyl is overwhelming. Yet, as Schmitz-Feuerhake observes, this evidence is ignored by the international radiation protection committees. These experts retreat from the evidence by fielding the stale argument that doses of radiation, estimated from environmental monitoring of cesium isotopes, are much too low to be responsible for the purported effects. According to these estimates, the mean effective lifetime exposure for people dwelling in large regions of Europe and Turkey was below **1.2 mSv** (UNSCEAR 1988). The highest average dose to a population in the first year after the accident occurred in Belarus and was estimated at **2.0 mSv**. The array of observed teratogenic effects at these doses scream out that the current science of radiation effects is deeply flawed. As to the problem, take your pick: (1) Environmental monitoring of cesium is a useless tool in estimating the "dose" to a population in the aftermath of a radiation release. (2) The people in Europe received much higher "doses" from Chernobyl than estimated. (3) Teratogenic effects can be induced by internal emitters at much lower "doses" than the corrupted Hiroshima data upheld by the radiation protection agencies would suggest. The spin-masters are pinned to the wall by this bind. Whatever option they choose, the masquerade disguising Chernobyl effects crumbles!

To navigate the morass of untruths and deceptions, Schmitz-Feuerhake proposes that biological dosimetry should be utilized to give more accurate dose estimates than the physical dosimetry of measuring environmental cesium:

> Investigations of unstable and stable chromosome aberrations in the lymphocytes of persons in the contaminated regions have been carried out by a variety of research groups in rather large collectives directly after the accident or some years later. Dicentric chromosomes can be considered as radiation-specific and most sensitive because of their very low and nearly constant rate in unexposed persons (Hoffmann and Schmitz-Feuerhake, 1999).
>
> It is generally found that the observed rates of dicentric chromosomes after Chernobyl are considerably higher — by 1 or 2 orders of magnitude — than would be expected from physically derived dose estimates. This evaluation is possible although the dose-effect relationships in cases of incorporated radioactivity are not known. For low dose homogenous exposure by low LET irradiation the rate of dicentrics can be considered as dose-proportional which follows from studies in the range of background exposure. In European countries, far from the Chernobyl site, the exposure of the tissues, except the thyroid, is assumed to be mainly generated by Cs137 and Cs134 which distribute homogeneously inside the body. The whole-body doubling dose for dicentrics by homogeneous low LET radiation is about 10 mSv (Hoffmann and Schmitz-Feuerhake, 1999). Elevations of dicentrics in persons which are higher than 2-fold would therefore mean that the whole-body dose exceeds 10 mSv. Such elevations have been found manifold after Chernobyl. A remarkable finding in many of the chromosome studies is that they report an overdispersion of the dicentrics and the occurrence of multi-aberrant cells (Bochkov and Katosova 1994; Hille *et al.* 1995; Salomaa *et al.* 1997; Scheid *et al.* 1993, Sevan`kaev *et al.* 1993; Stephan and Oestreicher 1989; Verschaeve *et al.* 1993). This is an indication of a relevant contribution of incorporated alpha-activity which is not considered adequately in the physical dose estimates.

The chart on the opposite page is reproduced from the Schmitz-Feuerhake article. It clearly demonstrates that "official" dose estimates for people living in certain areas of Europe are woefully inaccurate when compared to the biological dosimetry of chromosome aberrations in lymphocytes. Such a discrepancy once again casts doubt on the scientific integrity of those organizations who are supposedly protecting the world from radioactive pollution. The science speaks for itself: the population in many areas of Europe received much higher doses from Chernobyl than generally accepted and birth defects were induced from much smaller doses than suggested by ICRP science.

<u>Chromosome aberrations in lymphocytes of persons living in West European regions contaminated by Chernobyl releases;</u>

(dics = dicentric; cr = centric rings)

Region	Sample	Date of Study	Method	Results (mean elevation)	Reference	Remarks
Salzburg, Austria	17 adulsts	1987	dics + cr	Ca. 4-fold	Pohl-Rüling *et al.* 1991	
Germany: southern regions	29 chilrden + adults	1987-1991	dics + cr	Ca. 2.6-fold	Stephan, Oestreicher 1993	physical dose estimate <0.5 mSv
Norway: selected regions	44 reindeer Samis, 12 sheep farm-ers	1991	dics + cr	10-fold	Brogger *et al.*, 1996	physical dose estimate 5.5 mSv

In the article "The Chernobyl Catastrophe — 20 Years After (a meta-review)," Alexey V. Yablokov of the Russian Academy of Sciences summarizes the extensive research that has been carried out on the health effects from the accident. The congenital malformations which increased in frequency after 1986 included cleft lip and/or palate ("hare lip"), doubling of kidneys, polydactyly (extra fingers or toes), anomalies in the development of nervous and blood systems, amelia (limb reduction defects), anencephaly (defective development of the brain), spina bifida, Down's syndrome, esophageal and anorectal atresia, and multiple malformations occurring simultaneously. In 15 heavily contaminated districts in Belarus, the frequency of congenital malformations increased between 200% and 300% between the years 1982-1985 and 1987-1989. In a study of 30 areas with low levels of contamination, less than one curie per cubic kilometer, significant increases in the rates of many of the aforementioned congenital malformations were observed (Lazjuk *et al.* 1999).

The evidence from Chernobyl must be considered when assessing the hazards of depleted uranium. Low levels of environmentally dispersed radionuclides from the accident produced congenital malformations. This fact glaringly highlights that the main-

stream science of radiation effects, which denies that such malformations could have occurred, is wrong. The pronouncements of the official mouthpieces simply cannot be trusted. The whole enterprise is in disrepair. Scientists of integrity must step forward and finally put their house in order, for the reigning science is phony and the layperson can no longer buy into the lies.

Complementing the data from Chernobyl are other studies which have proven that low levels of radiation in the environment produce birth defects. One study was published by Padmanabham *et al.* under the title "Heritable Anomalies Among the Inhabitants of Regions of Normal and High Background Radiation in Kerala: Results of a Cohort Study 1988-1994." Although not a study of depleted uranium exposure, this research is pertinent to the discussion because it demonstrates that exposure to low levels of background radiation can influence pregnancy outcomes. The authors conducted a genetic epidemiological and fertility survey of 70,000 people in the region around Kerala, India. Part of the study population lived in regions where they received annual exposure to normal levels of background radiation, 85 to 100 mR/yr. (estimated from measurements taken 10 centimeters above the soil). The remainder dwelt in regions of significantly higher levels of background radiation produced by a high concentration of the mineral monazite in the soil which contains thorium, uranium and their radioactive daughters. Their estimated annual exposure averaged 563 to 735 mR/yr. (based on measurements taken 10 and 100 centimeters above the soil). Contrary to the propaganda matrix which insists that doses this low cannot possibly produce birth defects, this research revealed that those living in areas of high background radiation had a statistically significant increase in congenital malformations including Down's syndrome, autosomal dominant anomalies and multifactorial diseases. These findings were not an isolated occurrence. In their article, the authors mention similar studies conducted in areas of high background radiation which, on the whole, supported their findings:

> A cytogenetic study in the Brazilian HBRR [high background radiation region] with background radiation of 640 mR/yr. showed a significant increase in chromosome aberrations (Barcinsky *et al.*). Wei and colleagues reported a higher incidence of Down syndrome, chromosomal aberrations, and reactivity of T lymphocytes in Yanjiang County of China. Gopal-Ayengar and colleagues (1970) observed a higher incidence of cytological abnormalities and pollen sterility in four species of wild plants from the Kerala HBRR. However, Gruneberg and associates (1966) found no difference in musculoskeletal abnormalities in rats (Rattus rattus I.) from the HBRR and NRR [normal-radiation region]. In a cytogenetic study of 1,482 adults and infants from the Kerala HBRR and NRR, there was a 50 percent

> excess of aberrations among the subjects from the HBRR (George 1983, Cheriyan 1983). Nevertheless, in a survey of 2,381 couples from the HBRR and NRR, Gopal-Ayengar and colleagues (1972) did not find any difference in rates of fertility, mortality, and twinning. Kochupillai and colleagues (1976) reported a higher incidence of Down syndrome and severe mental retardation in the Kerala HBRR. George and co-workers (1989) did not find any significant increase of Down syndrome and other congenital anomalies in 3,000 infants born to parents from the HBRR.

Research on the teratogenic effects of depleted uranium in animals provides a theoretical basis for the possibility that such effects may also occur in humans. Domingo and colleagues, working at the University of Barcelona in Spain, have published a number of animal studies on the reproductive effects of DU in mice. Their work has demonstrated that the administration of UO_2^{++} to female mice, both orally and subcutaneously, leads to decreased fertility, embryonic and fetal toxicity, including reduced growth and malformations (cleft palate and skeletal defects), and developmental ossification variations (Hindin *et al.*). As interpreted by Domingo and his group, these aberrations were induced by uranium's chemical toxicity working on many levels: the molecular level (damaging DNA and RNA), at the cellular level, and/or at the organ level, affecting organs including the testes, placenta and embryo/fetus (Hindin *et al.*).

Other animal studies have demonstrated the teratogenic capacity of uranium. In "A Review of the Effects of Uranium and Depleted Uranium Exposure on Reproduction and Fetal Development," Arfsten, Still and Ritchie offer the following observations:

> Based on a review of the pertinent literature, there are several lines of evidence to suggest that DU exposure could potentially affect reproductive function and development in rodents. At this time, information on the reproductive and developmental effects of DU alloy in rodents is limited. However, existing data indicate that implanted DU translocates to the rodent testes and ovary, the placenta and fetus (Benson 1998; Pellmar *et al.* 1999a). DU has been shown to be genotoxic in *in vitro* cell model systems (Miller *et al.* 1998a) and possibly carcinogenic in rats (Hahn *et al.* 2002) suggesting that DU alloy could potentially disrupt or damage rapidly dividing cell populations in the fetus and the adult rat.
>
> Studies of the effects of natural uranium provide additional evidence that DU could have an adverse effect on rodent reproduction and development. Dosing of rodents with uranium has been shown to

> cause testicular toxicity, maternal toxicity, fetotoxicity, increased developmental variations and growth retardation independent of maternal toxic response (Domingo 2001). Intratesticular injection of enriched uranium compounds increased the incidence of cytogenic damage in developing mouse sperm (Hu and Zhu 1990). *In vitro* studies showed that uranium is both cytotoxic and genotoxic to Chinese hamster ovary (CHO) cells (Lin *et al.* 1993) and reduces cell number in developing mouse embryos in culture (Kundt *et al.* 2000).

The *Toxicological Profile for Uranium* has this to say on the toxic effect of uranium on fetal development:

> Because uranium can cross the placenta into the fetus, it is possible that uranium may have adverse effects on fetal development, especially metallotoxicity to the embryonic kidneys or the brain (Domingo *et al.* 1989b, 1989a; Paternain *et al.* 1989). The potential for teratogenicity and general developmental toxicity of uranium was demonstrated by results from oral animal studies in which the following were reported in mice: increased fetal mortality, reduced survivability, reduced growth (Paternain *et al.* 1989), reduced fetal body weight and length, an increased incidence of stunted fetuses, increased external and skeletal malformations and developmental variations, an increased incidence of cleft palate, underdeveloped renal papillae, and bipartite sternebrae, reduced or delayed ossification of the hind limb, fore limb, skull and tail, an increase in the relative brain weight of the offspring, a reduced viability and lactation index (Domingo *et al.* 1989a), and embryotoxicity (Paternain *et al.* 1989). These effects have not been observed or documented in any human study (ATSDR)

"In aggregate, the human epidemiological evidence is consistent with increased risk of birth defects in offspring of persons exposed to DU." This is the conclusion of Hindin, Brugge and Pannikkar in their article "Teratogenicity of Depleted Uranium Aeerosols: A Review From an Epidemiological Perspective." Their assessment that DU is a teratogene follows from two "compelling strands of evidence." First, plausibility has been amply demonstrated by the numerous *in vitro* and *in vivo* studies which confirm that uranium is genotoxic, cytotoxic and mutagenic. Second, this theoretical evidence is finding human expression in the documented cases of birth defects in areas of Iraq which suffered the heaviest DU contamination. When data gathered prior to 1990 on birth defects in southern Iraq are compared to data gathered after the environment was contaminated with DU, an upward trend in the rate of incidence exists for a number of different types of congenital malformations.

Hindin and her colleagues report on data gathered by a clinical epidemiology research team operating out of one of the three major maternity hospitals in Basra (Al-Sadoon *et al.*; Fasy). Since 1989, this group has maintained a congenital malformations registry which contains information on the health of all newborns assessed prior to discharge from the facility. The data gathered in 1990 is used as a baseline, representing a population unexposed to depleted uranium. In the years 1991 to 2001, the population was dwelling in contaminated lands. The annual birth rate ranged between 9,845 and 13,905. In 1990, the number of congenital malformations recorded in the registry was 37, representing an incidence rate of 3.04 per 1000 births. For the period 1991 through 1997, the number of congenital malformations hovered around the same rate, ranging from a low of 1.31/1000 to a high of 4.56/1000. But starting in 1998, an alarming trend began to be observed. That year, 79 babies were born with congenital malformations, a rate of 7.76/1000. In 1999, 136 malformed babies were born (9.78/1000). In 2000, 221 babies suffered congenital defects (17.6/1000). In 2001, the number rose to 254 (22.19/1000).

Hindin, Brugge and Panikkar created a redacted presentation of the data from the Basra Registry. The periods examined were 1990, 1991-94, 1995-98, 1999-2000. In addition, they classified the total number of congenital malformations into distinct diagnoses. By this means, progressive increases in the rates of several disorders were easily recognized. Among these were births with multiple congenital malformations, congenital heart diseases, cleft lip and palate, and phocomelia (an unusual skeletal malformation in which the limbs are abnormally short). An increasing trend in neural tube defects was also noted. (The most common types of NTDs are: anencephalia, hydrocephalus, spina bifida and meningomyelocele[2]. The overall incidence worldwide is 2.6 per 1000 total single births). Hindin reports this:

> Between 1990 and 1999–2000 the incidence of anencephaly rose from 2.5 to 17.4 per 10,000 births and of meningomyelocele from 7.0 to 11.3 per 10,000. The relative risk of these two NTDs among births in the study hospital for the years 1991–94, 1995–98, 1999–2000, in comparison to 1990, were 0.74, 1.31, and 2.91. By 1999–2000, the combined prevalence rate of anencephaly and meningomyelocele in the study hospital had reached 29/10,000.

In a separate study conducted by Al-Shammosy at the Diwaniah maternal and children's hospital north and east of Basra, the incidence of neural tube defects in 2000 was

[2] Anencephaly is a congenital defective development of the brain, with absence of the bones of the cranial vault and absent or rudimentary cerebral and cerebellar hemispheres, brainstem and basal ganglia. Meningomyelocele is a protrusion of the spinal cord and its membranes through a defect in the vertebral column (Stedman's Medical Dictionary).

8.4 cases per 1000. The types of defects noted included anencephaly, meningocele (protrusion of the membranes of the brain or spinal cord through a defect in the skull or spinal column), meningomyelocele and encephalocele (a congenital gap in the skull with herniation of brain substance.) In yet another study reported by Al-Taha at the Iraqi Congenital Abnormalities Clinic, a comparison was made of stillborns and children under two years of age born before and after the Gulf War. Among 1038 children examined in 1989-1990 compared to 945 children seen in 1992-1993, the incidence rate of anencephaly or hydrocephalus rose from 0.5% to 1.1% and the percentage of patients seen with skeletal abnormalities rose from 2.8% to 4.6%.

This quotation from an article in the *Guardian Unlimited* entitled "Victims of a War They Never Saw" paints a grim picture of the reality behind these statistics:

> For the past three months Dr. Zenad has been monitoring the birth defects in their delivery room, where 20 to 30 babies are born daily. She keeps her findings in a hard-backed grey notebook. She has divided the page into columns, in which she writes the sexes, dates of birth and weights of the babies. In a fourth column, she logs their deformities. She begins: "August - we had three babies born with no head. Four had abnormally large heads.
>
> In September we had six with no heads, none with large heads and two with short limbs. In October, one with no head, four with big heads and four with deformed limbs or other types of deformities."

These reports from Iraq give added credibility to a small study conducted in New Mexico which suggested a possible relationship between DU exposure and the frequency of hydrocephalus.[3] Rural and sparsely populated, Socorro County is located downwind of a DU-weapons testing site, the Terminal Effects Research and Analysis division of the New Mexico Institute of Mining and Technology. On average, 250 births occur yearly in the county. An investigation by a community activist revealed that between 1984 and 1986, five infants were born with hydrocephalus. (The normal rate of hydrocephalus is one case in every 500 live births). According to the demonstrably incomplete State of New Mexico's passive birth defects registry, between 1984 and 1988, 19 infants were born statewide with the condition, three of these within Socorro county. Regardless of which accounting is correct, the results are disturbing given that Socorro contains less than 1% of the state's population.

[3] Hydrocephalus is a condition marked by an excessive accumulation of cerebrospinal fluid resulting in dilation of the cerebral ventricles and raised intracranial pressure; may also result in enlargement of the cranium and atrophy of the brain. [Stedman's Medical Dictionary].

The impact of uranium on the developing fetus has not been thoroughly investigated. Due to uranium's affinity for bone, there are concerns that it may adversely affect skeletal development. In light of the observation that uranium crosses the placenta and is transferred from mother to fetus, the Royal Society has stated: "The effects of maternal exposure to DU on skeletal development in the fetus also need to be considered." Such caution is warranted in light of the fact that experiments on rats have demonstrated that both acute and chronic intakes of uranium can cause damage to bones (Makhijani, Smith and Thorne 2006). Often science finds disturbing echoes in peoples' lives. In September 2004, the *New Daily* reported the experience of Gerald Darren Matthew who served in the 719th Transportation company based in Harlem. Following deployment in the Gulf, he began suffering migraines, fatigue and a burning sensation while urinating. Undergoing proper diagnostic testing, he was found to be contaminated with DU. When his daughter, Victoria Claudette, was born, she was missing three fingers (Rose).

A further unknown exists as to the effect of uranium incorporated into bone on the bone marrow and the production of blood cells. Research conducted in 2004 heightens this concern. Arruda-Neto and colleagues exposed young beagle dogs to daily doses of uranyl nitrate and discovered that uranium accumulated in the marrow as much as in the bone. This was contrary to the results obtained from single, acute doses. If the marrow of the embryo likewise concentrates uranium, this raises concern about the possibility of uranium-induced leukemia. Further, it suggests a possible mechanism for damage to the immune system given that stem cells developing in the bone marrow are precursors to the various types of cells making up the immune system.

Another possible concern about uranium contamination in the fetus is its negative impact on the developing brain. As observed by Makhijani *et al.*: "uranium's primary chemical form in the body is as the uranyl cation (UO_2^{++}) which is a toxic heavy metal chemically analogous to the lead cation (Pb^{2+}) [Lemercier *et al.* 2003; Domingo 2001]. Thus, the known neurotoxicity of lead suggests that uranium may produce similar chemical effects. Similar to lead, uranium's chemical actions induce oxidative stress in the body, adversely affecting cellular structure and function. Further, like lead, uranium is known to cross the blood-brain barrier. When this is taken into consideration, along with uranium's radioactivity, warning flags go up that uranium may adversely affect the brain of the developing fetus.

There is some evidence to show that uranium may adversely affect hormone function. Whish and colleagues report that uranyl nitrate mimics estrogen activity *in vivo* and *in vitro*. In addition, some have postulated that uranium in the fetus may create hormonal or enzymatic disruption (Arfsten *et al.*; Domingo 2001). This possibility is mentioned by

Makhijani, Smith and Thorne in their article "Science for the Vulnerable: Setting Radiation and Multiple Exposure Environmental Health Standards to Protect Those Most at Risk":

> The potential for uranium to affect the hormonal systems is suggested by research on exposures to lead which shares chemical similarities with uranium in the body (Lemercier *et al.* 2003). Recent research has shown that both "prenatal and postnatal exposure to lead is associated with growth restriction in laboratory animals and humans" and that exposure to lead can also alter sex hormone production and delay puberty in rats (Selevan *et al.* 2003). An epidemiological study published in 2003 found that even relatively low average levels of lead caused a measurable delay in puberty in African-American and Mexican-American girls, whereas no statistically significant delay in non-Hispanic White girls was found. The observed effect on the girls' sexual development was tentatively attributed, at least in part, to potential "alterations in endocrine function (Selevan *et al.* 2003)." Many questions as to how lead caused the observed delay and whether or not the children had been exposed to higher levels in the past before the study's screening began remain unanswered. Nonetheless the potential for uranium to play an analogous role in affecting hormonally mediated processes in developing children could add further to its list of health concerns and could also add significant new avenues for potential synergisms with its other chemical and radiological health effects. This research also raises the question of the combined effects of exposure to uranium and hormonally active compounds. This is an area requiring further study.

A mysterious medical condition emerged from the Gulf War that may be related to the teratogenicity of depleted uranium. Upon returning home, a small number of veterans reported feeling a burning sensation after contact with their own semen. The wives of these men reported vaginal pain, swelling and burning after intercourse. Semen in contact with their skin produced such reactions as redness, burning, swelling, rashes and blood blisters. These were symptoms suffered by women in the general population who had localized or systemic seminal plasma hypersensitivity, an allergy to proteins found in semen. This condition has been linked to specific immunoglobulin E antibody which is triggered by seminal plasma protein antigens. Symptoms typically begin between five and 30 minutes after intercourse and can last from hours to days. In severe cases, a systemic reaction can occur involving breathing troubles/wheezing, hives, itching, dizziness, and in rare cases, vascular collapse or anaphylactic shock. Diagnosis of this condition relies on determining whether or not relief of symptoms occurs by use of a condom, preventing skin contact with

semen, and presence of the specific IgE antibodies. With perhaps the odd exception in the general population, men do not have allergic reactions to their own semen.

In an attempt to determine whether "burning semen syndrome" was identical to seminal plasma hypersensitivity, Jonathan Bernstein and colleagues at the University of Cincinnati College of Medicine undertook research on the subject. Included in their investigation was a posting on the internet of a screening questionnaire which was completed by 211 respondents. Approximately 75 percent (159 of 211) of those who participated in the Gulf War found the questionnaire through internet web pages that publicized the investigation to veterans throughout the United States and Canada. The remaining members of the study group answering the questionnaire were referred for evaluation by physicians from United States Veterans hospitals. Eighty-nine percent (188 of 211) of the respondents had either personally experienced burning after contact with their own semen or had a sexual partner who felt burning sensations after contact with their semen. As a control group, the questionnaire was distributed to 1073 women in the general population who suspected they had symptoms of localized and/or systemic seminal plasma hypersensitivity. Of these, 12 percent fulfilled the diagnostic criteria.

Of the 211 people filling out the questionnaire, only seven percent (15 of 211) reported having symptoms of burning semen syndrome prior to being dispatched to the Gulf. By contrast, 48 percent (101 of 211) developed symptoms immediately after their first sexual contact upon returning home. Fewer than 50 percent (97 of 211) of the Gulf War couples reported relief of symptoms by use of a condom. For women suffering from seminal plasma hypersensitivity in the general population, 100% report complete relief after condom use.

Bernstein and his colleagues summarize the results of their research as follows:

> The common denominator of Gulf War burning semen syndrome and seminal plasma hypersensitivity in the general population are the symptoms of localized vaginal burning and pain immediately after contact with semen. However, the initial questionnaire survey and subsequent clinical evaluation revealed cogent differences. In seminal plasma hypersensitivity occurring in the general population, the man is typically asymptomatic, and skin test responses to homologous semen are negative. Symptoms experienced by women invariably disappear after use of a condom. In contrast, male partners in the Gulf War burning semen syndrome often complain of burning after contact with their own ejaculates, and several of the men in this study also exhibited positive skin tests to their own seminal plasma proteins.

Moreover, less than half of the Gulf War female partners experienced relief of symptoms if partners used condoms correctly. The questionnaire survey revealed that many Gulf War couples with burning semen syndrome exhibited other features of the Gulf War syndrome, which tended to complicate the clinical evaluation and ultimate diagnosis of burning semen syndrome. When Gulf War veterans were divided into "healthy" and "unhealthy" groups, a significant correlation between post-traumatic stress disorder and the "unhealthy" group was established. For this reason, Gulf War veterans who did not have irrelevant concomitant somatic/psychologic complaints and their sexual partners were preferentially selected for the treatment phase of this project to evaluate responses to therapy exclusive of these possible confounders.

In general, both women from the general population and female partners of Gulf War veterans exhibited specific IgG and IgE antibody responses to whole seminal plasma. However, as previously reported, the results of this study demonstrated that IgE-mediated skin testing, with or without confirmatory *in vitro* specific IgE antibody responses, was the best predictor of successful outcome after seminal plasma protein desensitization in either the general population or Gulf War female partners. The combination of specific IgE skin tests to seminal plasma protein and successful therapeutic responses to rapid desensitization in three of these Gulf War couples indicates that burning semen syndrome is induced by an IgE-mediated mechanism in a subpopulation of Gulf War couples presenting with this problem. The cause(s) of non-IgE mediated burning semen syndrome remains to be determined.

Several Gulf War and male subjects from the general population were noted to also produce low levels of specific IgG and IgE antibody to their own seminal plasma protein. Indeed, three of four Gulf War men also demonstrated IgE-mediated skin test reactivity. The significance of these findings is unknown but could represent either exogenous cross-reactivity between common environmental proteins or immunologic mimicry resulting in autoantibodies to one or more seminal plasma protein antigenic determinants in men. One or both of these possibilities is suggested by the fact that the vast majority of patients claiming to have burning semen syndrome by history did not have these symptoms before the Gulf War exposure. Further work is necessary to determine whether antibody responses in male subjects have a functional role in the underlying immunologic phenomena

> associated with seminal plasma hypersensitivity and burning semen syndrome.

Simply stated, the results of Bernstein's group demonstrate that the symptoms experienced by a portion of Gulf War couples can be explained as an expression of seminal plasma hypersensitivity. However, the remainder are suffering symptoms as a result of exposure to some noxious agent during service in the Gulf. Obviously, further research is warranted. Given that depleted uranium is known to be deposited in the testes and has been found in the semen of veterans, it is a prime candidate for study. As of this writing, there are no reports in the published literature that semen from veterans experiencing burning semen syndrome has been subjected to isotopic analysis of uranium.

To put a human face on this topic, the experience of Terry Riordon and his wife, Susan, is very moving. Terry was a captain in the Canadian Armed Forces. Prior to his service in the first Gulf War, he was a cross-country skier and a marathon runner. After serving for two months in the Gulf, he returned home in February 1991. At that time, he could barely walk. He had documented loss of motor control, chronic fatigue, respiratory difficulties, chest pain, difficulty breathing, sleep problems, short-term memory loss, testicle pain, body pains, aching bones, diarrhea and depression (www.umrc.net). After his death in April 1999, an autopsy was performed. Tests confirmed the presence of depleted uranium in his lungs and his bones.

In an article published in *Vanity Fair* in 2004, Susan Riordon offered these poignant memories:

> At first, Terry merely had the usual headaches, body pain, oozing rash, and other symptoms. But later he began to suffer from another symptom which afflicts some of those exposed to DU: burning semen. "If he leaked a little lubrication from his penis, it would feel like sunburn on your skin. If you got to the point where you did have intercourse, you were up and out of that bed so fast — it actually causes vaginal blisters that burst and bleed."
>
> "It hurt [Terry] too. He said it was like forcing [semen] through barbed wire," Riordon says. "It seemed to burn through condoms; if he got any on his thighs or his testicles, he was in hell." In a last, desperate attempt to save their sex life, says Riordon, "I used to fill condoms with frozen peas and insert them [after sex] with a lubricant." That, she says, made her pain just about bearable. Perhaps inevitably, he became impotent. "And that was like our last little intimacy gone" (Rose).

Depleted Uranium is Neurotoxic

By means of its radiation and its chemistry, depleted uranium is a neurotoxic agent. Delivery into the body in the form of nanoparticles further enhances this neurotoxicity. These various vectors, both alone and synergistically, affect the structure and function of the nervous system and manifest themselves in altered behavior and, perhaps, in disturbed cognition.

As noted earlier, nanoparticles exhibit unique patterns of behavior within the body. Their billionths-of-a-meter dimensions permit entry into cells, transport across cells (vesicular transport) and translocation along neurons. As a delivery vehicle, nanoparticles are particularly effective in transporting uranium and other toxic metals to unexpected sites of deposition where their surface chemistry, charge, shape and radioactivity impact local biochemistry and cellular structure and function.

A fraction of battlefield uranium is delivered to victims in the form of nanoparticles. Research has shown that such combustion-derived nanoparticles have easy access to the brain. Oberdörster and associates (2004) demonstrated that radiolabeled carbon nanoparticles translocated directly from the noses of rats into their brains. Commenting on their research, the authors offered this observation:

> We conclude from our study that the CNS can be targeted by airborne solid ultrafine particles and that the most likely mechanism is from deposits on the olfactory mucosa of the nasopharyngeal region of the respiratory tract and subsequent translocation via the olfactory nerve. Depending on particle size, >50% of inhaled UFP can be depositing in the nasopharyngeal region during nasal breathing. Preliminary estimates from the present results show that ~ 20% of the UFP deposited on the olfactory mucosa of the rat can be translocated to the olfactory bulb. Such neuronal translocation constitutes an additional, not generally recognized clearance pathway for inhaled solid UFP, whose significance for humans, however, still needs to be established. It could provide a portal of entry into the CNS for solid UFP, circumventing the tight blood-brain barrier. Whether this translocation of inhaled UFP can cause CNS effects needs to be determined in future studies.

Oberdörster, in an article published in 2005, gave other examples of how nanoparticles translocate to the brain:

> There are additional neuronal translocation pathways for solid NSPs via the trigeminus nerve and tracheobronchial sensory nerves. A study by Hunter and Dey (1998) in rats demonstrated the translocation of intranasally instilled rhodamine-labeled microspheres (20-200 nm) to the trigeminal ganglion inside the cranium via uptake into the ophthalmic and maxillary branches of the trigeminus nerve that supplies sensory nerve endings throughout the nasal mucosa. In another study, Hunter and Undem (1999) instilled the same microparticles intratracheally into guinea pigs; they found neuronal translocation of these solid microparticles to the ganglion nodosum in the neck area that is networked into the vagal system. This finding may be relevant for ambient UFPs because it can be hypothesized that cardiovascular effects associated with ambient particles in epidemiologic studies (Utell *et al.* 2002) are in part due to direct effects of translocated UFPs on the autonomic nervous system via sensory nerves in the respiratory tract.

Other studies have further confirmed that inhaled nanoparticles achieve deposition in the brain. Rats exposed to stainless steel welding fume for a period of 60 days showed an accumulation of manganese in various areas of their brains (Yu *et al.*). Erikson and colleagues demonstrated that inhalation of manganese sulphate and manganese phosphate was responsible for producing oxidative stress in the brains of their test animals. In humans, workers exposed to welding fume show unmistakable evidence of neurological disease (Sadek *et al.*).

It is worth noting that cardiac function may be disturbed by indirect effects of nanoparticles on the nervous system. Donaldson *et al.* (2005) cite evidence that nanoparticles in air pollution can adversely affect cardiovascular physiology by altering heart rate variability. One hypothesis put forward to explain this effect is that "particles enter the interstitium and/or cause inflammation which affects the autonomic nerve endings that regulate the heart rhythm leading to dysrhythmia." This proposed mechanism may produce untoward physiological effects anywhere in the body. Nanoparticles can induce inflammation in the tissues in which they are deposited. This inflammation may, in turn, adversely affect nerve function. This underlying condition would then become manifest as a number of different expressions of pathophysiology.

Animal studies have confirmed that the brain is a target organ for internalized depleted uranium. Pellmar and his colleagues at the Armed Forces Radiobiology Research Institute demonstrated that when mice were implanted with pellets of DU, the DU translocated to a number of different regions of the brain (Pellmar *et al.* 1999a). Further, they

noted that the quantity of DU deposited in the brain was directly related to the amount of DU internalized in the body. Research conducted by Ozmen and Yurekli (1998), Lemercier *et al.* (2003), and Fitsanakis *et al.* (2006) substantiated that internalized DU migrated to the brains of mice and rats. The presence of DU in the brain was proven to produce electrophysiological changes in the hippocampus (Pellmar *et al.* 1999b; Lemercier *et al.* 2003). (These researchers chose the hippocampus for study because it is the region in the brain involved in learning, memory consolidation and spatial orientation functions [Jiang and Aschner]. One conclusion that emerged from Pellmar's work and the work of Lestaevel *et al.* requires emphasis. As stated by Makhijani and Smith: "***we note that recent experiments in mice have shown uranium effects on the brain with potential neurotoxicological importance at levels of uranium exposure that were not found to cause discernible damage to the kidneys***. (Pellmar *et al.* 1999b.; Jiang and Aschner; Makhijani and Smith 2004)

The accumulation of uranium in the brain has been proven to be associated with behavioral changes. In a study by Monleau and colleagues, male rats received repeated exposure, via inhalation, to uranium dioxide. At the end of the exposure period, uranium concentrations in various parts of the brain were measured. The highest concentrations were found in the olfactory bulb. Then, from greater to lesser concentration, uranium was found to accumulate in the hippocampus, frontal cortex and cerebellum. Deposition of DU in the brain was accompanied by behavioral changes. At one day after exposure, spontaneous locomotion activity increased. After six days, spatial working memory was found to be less efficient when compared to a control population. This observation of behavioral changes in contaminated animals was not an isolated occurrence. Abou-Donia and fellow researchers at Duke University used rats to study the effects of injections of uranyl acetate on sensorimotor behavior, nitric oxide generation and the central cholinergic system. Thirty days after the test animals received injections of 0.1 and 1.0 mg/kg of uranyl acetate in water, the animals were put through a battery of tests designed to evaluate sensorimotor functions. These tests included measurements of postural reflexes, limb placing, orientation to vibrissae touch, grip time, beam walking and inclined plane performance. At the completion of the tests, the animals were sacrificed and the cerebral cortex, brainstem, cerebellum and midbrain were dissected. Determination was made of the levels of nitric oxide, a marker for increased oxidative stress, and the integrity of the cholinergic system as reflected in acetylcholinesterase (AChE) activity and m2 muscarinic acetylcholine receptors ligand binding. The researchers noted a dose-related deficit for inclined plane performance. Both dose groups showed reduced grip time and impairment in both beam-walk score and beam-walk time. A significant increase in nitric oxide was seen in the low dose group in the cortex and midbrain. Brainstem and cerebellum showed an insignificant decrease at both doses. Interestingly, there was no significant change in the levels of nitric

oxide in the kidneys or the livers when compared to the controls. A significant increase in acetylcholinesterase activity was noted in the cortex of the animals receiving the higher dosages but not in other brain regions. Ligand binding densities for the m2 muscarinic receptor did not show any change. The researchers offered this conclusion from their study: "These results show that low-dose, multiple exposure to uranyl acetate caused prolonged neurobehavioral deficits after the initial exposure has ceased."

Briner and Murray put depleted uranium acetate in the drinking water of male and female rats in various concentrations and for different lengths of time. At the end of the exposure period, the behavior of the animals was tested in the open-field. After these tests, the brains were examined for levels of lipid oxidation. The researchers stated their conclusions as follows:

> Behavioral differences (line crossing and rearing) were seen in male rats after 2 weeks exposure to DU in drinking water for the highest dose group. Increased brain lipid oxidation was seen for the highest dose group for both genders. Lipid oxidation levels correlated significantly with line crossing and rearing in the open-field. After 6 months exposure, behavioral differences for male rats in the open-field remained and expanded to include other behaviors (grooming, defecation and urination). Female rats also demonstrated some behavioral changes after 6 months exposure. Lipid oxidation in the brain continued to be seen; however, these levels no longer correlated with open-field behaviors. **These data suggest that DU is a toxin that crosses the blood-brain barrier, producing behavioral changes in male rats and lipid oxidation regardless of gender in as little as 2 weeks in the rat** [emphasis added]. Longer exposures to DU may produce greater behavioral changes but compensatory mechanisms may reduce the effects of lipid oxidation. Males appear to be more sensitive to the behavioral effects of DU.

One area that screams out for study is the neurotoxicity of depleted uranium on the developing fetus. According to the ICRP, based on the data from the survivors of the atomic bomb, prenatal irradiation to the developing central nervous system can be responsible for mental retardation, decreased intelligence scores and school performance, and seizure disorders (ICRP 90). The ICRP further notes:

> Development of the central nervous system starts during the first weeks of embryonic development and continues through the early postnatal period. Thus development of the central nervous system occurs over a very long period, during which it is especially vulnerable.

> It has been found that the development of this system is very frequently disturbed by ionizing radiation, so special emphasis has to be given to these biological processes (ICRP 90).

It's important to note that the ICRP model of radiation effects on early embryonic development woefully underestimates the potential damage from alpha-emitting radionuclides. According to Makhijani, Smith and Thorne:

> As with a number of other emerging risks from uranium, there is thus the potential for synergisms between uranium's chemical and radiological effects in relation to its effects on the nervous system that need to be further investigated. Moreover, it is important to note in this context that the radiation dose model adopted by the ICRP for the first eight weeks of pregnancy is not suitable for alpha-emitting radionuclides. The ICRP assumes that the dose to the embryo/fetus in this period is the same as that to the maternal uterine wall (ICRP 88). This model is not really relevant to alpha-emitting radionuclides, since alpha particles deposit their energy in a very short range. Uterine dose from such particles may have little or no relation to the dose to the embryo/fetus.

It has been suggested that uranium is sufficiently analogous to lead to warrant concern that DU may be particularly harmful to the developing nervous system of the fetus and young child. In 2004, Makhijani and Smith summarized their concern with these observations:

> There are clear indications that uranium toxicity for at least some effects, including its neurotoxic effects on fetuses and young children, might be better understood if uranium was considered to be analogous to a kind of radioactive lead, in which the damage from the alpha radiation occurs in conjunction with heavy metal induced damage to produce a variety of health problems at relatively low levels of exposure. This analogy between uranium and lead was made in 2003 by Lemercier *et al.* in reporting their study demonstrating the concentration of uranium in the brain of rats. While this way of thinking has obvious limitations in regards to understanding the detailed biological mechanisms involved in the damage caused by uranium as compared to lead, the ability of uranium to chemically induced oxidative stress, to cross the blood-brain barrier and alter electrical activity in parts of the higher brain, and to potentially interrupt neurotransmitters through chemical replacement of calcium in the interneuron

> gaps all in combination with the high levels of local cellular damage caused by alpha radiation raise significant warning signs about the potential impact of this material on a child's developing brain.

Much has been said in this chapter of the capacity of nanoparticles and uranium's chemistry and radioactivity to produce oxidative stress. Consequently, it is important to recognize that oxidative stress is recognized as playing a role in a wide range of neurodegenerative diseases. The brain is considered particularly susceptible to reactive oxygen species due to its high metabolic rate and its reduced capacity for cellular regeneration. An accumulating body of evidence clearly demonstrates that oxidative stress is a factor in chronic neurodegenerative disease such Alzheimer's disease, Huntington's disease, Parkinson's disease, amyotrophic lateral sclerosis, schizophrenia and prion disease. Reviewing the research of the relationship between depleted uranium and oxidative stress, Jiang and Aschner offer this summation:

> An appealing hypothesis for the specific mechanism by which DU leads to neurotoxicity is that DU results in oxidative stress, which could potentially lead to cell death, perhaps by apoptosis. It has been demonstrated that uranyl compounds have a high affinity for phosphate, carboxyl, and hydroxyl groups and easily combine with proteins and nucleotides to form stable complexes (Weir). Furthermore, DU leads to oxidative DNA damage by catalyzing hydrogen peroxide and ascorbate reactions (Miller *et al.* 2002c), as uranium with ascorbate in the presence of hydrogen peroxide leads to single-strand breaks in plasmid DNA *in vitro* (Yazzie *et al.*). Evidence for induction of oxidative stress and reactive oxygen species (ROS) by DU has been shown by increase in NO in rat brains (Lemercier *et al.*), brain lipid oxidation (Briner and Murray), transcriptomic, and proteomic changes in kidney cells (Taulan *et al.*; Prat *et al.*). Moreover, some studies indicate that heat shock proteins might be involved in the cellular response to DU exposure and acquired resistance to uranium rechallenge (Furuya *et al.*; Mizuno *et al.*; Tolson *et al.*). These data strongly suggest the possibility that uranium might result in the formation of ROS, leading to cell death via apoptotic mechanisms. Support for an apoptotic mechanism comes from studies by Kalinich and colleagues, who demonstrated significant apoptotic events in mouse macrophage cells treated with 100 microM DU (Kalinich *et al.* 2002).

Conclusion:

When the United States government elected to introduce uranium weapons into

combat, it catastrophically overreached itself. The effects of DU drew undue attention to a very sophisticated propaganda matrix that had been used by the US for half a century to deflect criticism of its nuclear pursuits. As each new war zone became contaminated with uranium, reports began accumulating of nonspecific illnesses, increased frequencies of birth defects and cancer — all epidemic in scale. An investigation into the veracity of these claims caused a new light to be shone on the reigning science of radiation effects. It revealed that the scientific committees in many parts of the world manufacture the status quo in scientific thinking by dictating what the rest of us are to believe as to what is true and what is false. The gaping disparity between the pronouncements of these organizations on uranium's radiological effects and chemical toxicity and the effects documented in contaminated populations uncovered a fraudulent science whoring for those who wish to dominate others with nuclear and radiological weapons. This revelation is the only benefit derived by humankind from the hideous DU weapons.

When one reads the studies of the toxicity of uranium in works published by the Royal Society, the World Health Organization, the US Department of Health and Human Services, the Rand Corporation and so forth, one is hard-pressed to glean any reasonable association between uranium exposure and the diseases emerging in the war zones. But that is their whole reason for being. They are designed to obstruct understanding and turn attention away from the fact that crimes against humanity are in progress. In support of this observation is the fact that when current research is examined, all of a sudden the picture of uranium's toxicity metamorphizes. Internalized uranium seems quite capable of producing subtle perturbations in many different organ systems, leading for example to the symptoms of Gulf War Disease. DU may be responsible for the rise in the frequency of birth defects in Iraq. DU may be responsible for the leukemia reported in NATO peacekeepers. What prevents widespread acknowledgment of these possibilities and discourages relevant research is the obstructionistic science, funded by a political agenda, that seeks to discourage free thought and pioneering inquiry.

This entire book, while investigating the science that whispers lies into the ears of mankind about depleted uranium, has been an exposé of apocalyptic importance. Readers of the Bible have for two centuries pondered the identity of the Great Harlot. Living in End Times, we alive today have a unique perspective that allows us to reveal her identity to history. What was revelation to people of previous generations is for us today the stuff of newspaper headlines. Daily, we witness false testimony by scientists who sully truth on behalf of corporate gain, political advantage or military power. Researchers shill for the pharmaceutical companies, the biotech companies, the food producers, producing false studies on drug effectiveness, the safety of genetically modified seeds, the nutritional value of sugar and fat laden processed foods. With but one intent, the Great Harlot has a thou-

sand faces: to beguile in the furtherance of greed and power.

Be not mistaken. This diatribe is not aimed at demeaning science. It is penned to unmask the corruptors who have kidnapped science and debased our cherished beliefs and beloved institutions, all for their personal aggrandizement. As witnessed in these pages, the true heroes of our age are the independent scientists who do not allow their quest for truth to be stomped out by government and profit. In their hands, science is humanity's single most potent tool for discovering truth, exposing corruption and resisting tyranny. As long as some amongst us stand for truth, the Great Harlot is made ugly and her paramours dally only with perdition.

Those who wield vile weapons are enamored with destruction. *They love to destroy*. This is the hidden secret in their hearts. Made impotent by their moral destitution, they cannot create anything beautiful or nurturing or life-enhancing. All they know is how to corner markets, build portfolios, amass fortunes and stomp of the lives and dreams of those that stand in their way. They attempt to fill the emptiness in their hearts with insatiable greed. They compensate for their spiritual emptiness by striving for unchallengeable power. They cover their indifference to life and nature with lies. They are pimps who have lured noble science into harlotry. The painted face of this whore masks their atrocities.

But now, stripped of her glass jewelry, the Great Harlot stands before mankind ugly and forlorn. Her makeup smeared, her once famous beauty is now so much artifice. Proud science, forced to prostitute itself, is forever saddled with a tarnished reputation.

The kings of the earth, be they politicians or CEOs, are not the only ones who committed fornication with the Great Harlot of Babylon. We all stand complicit. We are drunk with the wine procured from a science devoted to profit and a plundering of resources. Daily, we dance on the edge of a precipice. A moment from now, a nuclear apocalypse may consume the Earth. The wastes of our revelries are poisoning the air, polluting the waters and exterminating species. Greed has turned us away from our stewardship of the earth. Distracted by technological glitter, we allow crooks and debased human beings to ascend to positions of leadership. We unwittingly conspire against ourselves by giving the conspirators the keys to our earthly kingdom.

> *"Come, I will show you the judgment of the great harlot who sits on many waters, with whom the kings of the earth committed fornication, and the inhabitants of the earth were made drunk with the wine of her fornication."*

14

The Key to Gulf War Syndrome — Has It Been Discovered?

As this book is being prepared for publication, cutting edge research is producing results strongly suggesting that a single cause does in fact underlie Gulf War Syndrome. On August 20, 2007, the Discovery Channel aired an episode of its series Conspiracy Test entitled *Gulf War Illness*. During the program, the results of research undertaken at the Molecular Medicine and Genetics Lab at Wayne State University were presented. In a preliminary study supervised by Dr. Henry Heng, blood samples were collected from five veterans of the 1991 Gulf War who were suffering symptoms of the undiagnosed illness they had contracted while in military service. Although not stated during the show, these veterans had previously tested positive for DU contamination. (This fact was later made known by staff of the Uranium Medical Research Center.) One criterion for participation in this study was that a veteran could not have served in any area where possible exposure to chemical warfare agents might have occurred as a result of the destruction of weapon caches at Khamisiyah. Using spectral karyotyping (SKY), Heng and his graduate students imaged and analyzed the chromosome structure in the blood cells of the veterans. Spectral karyotyping is a laboratory technique that allows scientists to rapidly and inexpensively visualize all 23 pairs of chromosomes within a cell. This methodology was first introduced by Schröck and colleagues at the National Center for Human Genome Research in Bethesda, Maryland, in 1996 (Schröck *et al.*). In spectral karyotyping, a large number of short sequences of single-stranded DNA are prepared. These probes are structured to complement unique regions along the entire length of each chromosome. All the probes designated for a particular chromosome are labeled with the same fluorescent color. When the probes are mixed with chromosomes from a cell, they bind to the DNA and paint each chromosome a different color. Computer analysis can then rapidly detect any structural abnormalities in the chromosomes.

What Heng and his colleagues found using this technique was dramatic and startling. The karyotype of each of the veterans clearly displayed significant levels of chromosome damage. According to Heng, the damage widely exceeded that observed in cancer patients. Translocations, broken chromosomes, centromere displacements and aneuploidy (a gain or loss in the number of chromosomes) were observed. According to Heng, the chromosome aberrations observed were typical of the type of damage produced by radiation. As would be expected, the karyotype of each veteran was unique, exhibiting a different pattern of chromosome abnormalities. Since radiation damage is a random process, the damage it produces to the DNA in each cell is different.

From this preliminary and very tentative research, it is tempting to speculate that the key to understanding Gulf War disease has been found. The seemingly unrelated ailments suffered by veterans do indeed have a definite biological marker: significant structural abnormalities of the chromosomes. The observed diversity of symptoms is an external expression of the genetic chaos induced in a huge number of somatic cells, all malfunctioning in different ways depending on the type of chromosome damage incurred by each. Different cell types in different parts of the body may be involved, producing an array of symptoms unique to each individual. If this is the case, Gulf War Illness is a new type of disease, one not defined by a shared set of symptoms but by significant random disturbance in the genetic structure of each afflicted individual. Speculating further, weaponized uranium is a likely candidate for producing this type of widespread genetic damage due to its mobility once inside the body and because of uranium's affinity for DNA. Confirmation of this hypothesis awaits controlled study, peer review and publication.

Humanity is one study away from penetrating the fog of lies and deceptions surrounding Gulf War Disease and depleted uranium weaponry. What is required is a study group of ill veterans. This cohort needs to be assessed for the presence of DU in their urine. Their chromosomes must be analyzed by spectral karyotyping. If ill veterans are discovered to be contaminated with DU and their chromosomes simultaneously manifest significant structural abnormalities, Gulf War Illness will be a mystery no more.

A second research project would be most interesting. Spectral karyotyping might be performed on veterans wounded with DU shrapnel and those contaminated by DU through inhalation. The results obtained from the two groups could then be compared. This study would help to prove or disprove the hypothesis that inhaled weaponized uranium produces different effects from the slow leaching of uranium into the circulation from a piece of embedded uranium metal.

The proposed study could only be undertaken by brave researchers who can remain

steadfast and undaunted by the wrath they will draw upon themselves from the nuclear establishment. The stakes of this line of investigation are momentous, far greater than uncovering a possible relationship between DU and Gulf War Illness. The entire house of cards, built to conceal the true biological consequences of radiation exposure, teeters on this simple investigation. If a correlation is ever definitively established between internal contamination by DU and significant chromosome aberrations, all the major tenets of this book will be validated, namely that:

— The effects of weaponized uranium cannot be accounted for by currently accepted dose/response models.

— The concept of "dose" when applied to the nonuniform distribution of certain radionuclides in the body is antiquated and fraudulent.

— The ICRP maximum permissible dosages, for at least certain internal emitters, are bogus.

— The ICRP risk factors are completely out of line with reality.

— The Hiroshima Life Span Study has nothing relevant to say regarding internal exposure.

— The nuclear industry misleads humankind regarding the hazards of ionizing radiation.

— Exposure to extremely low levels of internal emitters can be detrimental to health.

— Radiation exposure can produce a spectrum of ailments in addition to cancer.

— Low levels of internal exposure do produce genetic defects.

— The current theory of radiation effects, upon which safety standards are derived, is hopelessly reductionistic because it fails to adequately address the unique biokinetics and biochemistry of each radionuclide and the synergy created by each radionuclide's physical, chemical and radiation effects.

— All the research on Gulf War Illness that failed to seriously entertain radiation exposure as a causative factor was misdirected.

—Gulf War Illness is a new and unique disease entity, and depleted uranium is either the factor responsible or a cofactor in its etiology.

—DU weapons must be immediately banned because their use is a crime against humanity.

15

A Short History of Radiological Warfare

The dispersal of depleted uranium over the Iraqi homeland during Operation Desert Storm in 1991, and in Bosnia, Kosovo, Afghanistan and a second time in Iraq in 2003, was the revamping of a strategy originally conceived during the Second World War. In 1941, meetings were convened by a committee of the National Academy of Sciences to study the feasibility of developing the atomic bomb. It was amongst this group that the idea first surfaced of breeding radioactive material within a nuclear reactor and using it as a poison against the enemy. A report published in May of that year listed the first option of an atomic program as the "production of violently radioactive materials carried by airplanes to be scattered as bombs over enemy territory" (Ford). In the months following, this amplification of warfare became a topic of increasing concern. By the end of 1942, there was widespread anxiety among Manhattan Project physicists, many of whom had emigrated from Nazi Germany, that the colleagues they had left behind were engaged in radiation research on behalf of the Third Reich. It was feared that their work would enable Hitler to acquire radioactive material that could be used as a weapon against Allied forces in Europe or against the American homeland.

A similar fear was projected onto the Japanese Fu-Go program during the last year of the war. Large balloons, 32 feet in diameter, were fabricated from laminated mulberry parchment paper and held together with persimmon glue. These were then filled with hydrogen and set aloft to travel across the Pacific and bomb the US. Each balloon was outfitted with five or six incendiary bombs and one 30-pound conventional bomb.

Approximately 9,300 of these balloons were launched. The hope was that the balloons would start forest fires and promote panic in the population. It is estimated that 1,000 balloons actually made it to the North American continent. Little damage of any kind was ever produced by this effort. But during the course of this campaign, apprehension grew among Manhattan Project personnel that some balloons might be used as vehicles for transporting microscopic uranium particles for the purpose of contaminating heavily populated urban centers. This fear is indicative of the concern these scientists shared about the possible outbreak of radiological warfare.

As an aside, there is an interesting historical anecdote about the Fu-Go program.

> To add a strange twist to this story, another balloon managed to knock out power to the Hanford Engineering Works in eastern Washington state. This caused a temporary short circuit in the lines to their nuclear reactor cooling pumps where they were cranking out uranium slugs for the Nagasaki atomic bomb. Backup devices kicked in, but production at the plant was set back for three days and caused a slight delay to the Manhattan Project (Fu-Go).

Among the developers of the atomic bomb, there were some who were gripped by mounting apprehension that the Germans would be the first to initiate radiological warfare. This concern led to the establishment of a committee, comprising James Bryant Conant, Arthur Compton and Harold Urey, to study the possibilities and implications of waging radiological warfare. Their report appeared in 1943 and was entitled *The Use of Radioactive Material as a Military Weapon* (Conant *et.al.*). Out of historical interest, parts of this memorandum are reproduced below. It is important to note that the radionuclides being considered at that time as agents for radiological warfare are nowhere mentioned. From the context of the memo, one can assume that reference was being made to a blend of fission products produced in a nuclear reactor. As such, the anticipated effect of this blend as a terrain contaminant would be akin to that created by the detonation of a nuclear weapon or a Chernobyl-type reactor accident. Quite obviously, the radioisotopes under consideration are vastly more radioactive than those of uranium. What the memorandum clarifies is that from the very beginning of the nuclear age, internal contamination with radioactivity and the resulting debilitation in health was considered a viable method of waging war. Further, it outlines the principles of radiological warfare that are being witnessed today in areas where uranium weapons are being deployed: to induce sickness and death in enemy troops and civilian populations, to render terrain uninhabitable, and to incite panic.

Report of Subcommittee of the S-1 Committee on the use of radioactive material as a military weapon.

A. Availability of Material

1. There can be no question but that it is now possible to prepare large quantities of radioactive material in connection with the operation of what is known as either the graphite or the heavy water pile. As the plans now stand in the United States, it should be possible when the full units are in operation along these lines to produce approximately the equivalent in radioactive effect of one ton of radium every four days. Since the material produced is approximately 100,000 times more active than radium itself, the actual quantity of material produced will be very much less than a ton, indeed will only be approximately 20 grams in the pure state and not more than 100 lbs. in the impure form in which it might readily be obtained as a byproduct of the pile.

B. Contamination of Large Areas of Enemy Territory

2. On the basis of the present available information, it has been estimated by those who are most familiar with biological effects of radioactivity that if the equivalent of a ton of radium (which in scientific terms is called 10^6 curies) were uniformly distributed over an area of approximately two square miles of open fields, the area so contaminated could not be occupied by human beings with safety except for short periods or time. Based on calculations and on some preliminary experiments carried out on a small scale by Dr. Stafford Warren, it would seem that the radiations over such territory would correspond to approximately 50 to 100 roentgen units per day at the height of one meter above the ground.

In an area so contaminated, exposure for a few hours would probably produce little or no effect, but exposure for one day would give temporary incapacitation for a large fraction of those so exposed; exposure for two or three days would give prolonged incapacitation and in some cases death would ensue. The area would be lethal for those who occupied it for more than a week. Hence, evacuation would be necessary. Since the effects of such exposure are delayed by days and sometimes weeks, the weapon would be of little value as a means of quickly putting out of immediate action those who were exposed. On the other hand, extraordinarily high concentrations might cause

symptoms to appear in a few hours. For example, concentrations five to ten times the amount considered in the preceding paragraph (i.e. 500 to 1000 roentgens per day) would be lethal in a day and would seriously incapacitate after a few hours' exposure. These concentrations could be distributing 10^6 curies over 0.2 to a half of a square mile. The availability of material, however, might limit such heavy dosage to something like two such applications per week or the equivalent.

Areas contaminated by radioactive materials would continue to be dangerous until the natural decay of the radioactivity had lowered the radiation to a safe point. With the materials in view, this would require many weeks if not months.

This persistence of contamination in spite of all efforts to decontaminate constitutes the chief tactical advantage of this weapon as compared to contamination with mustard gas or lewisite. If the surface were hard, some decontamination might be accomplished by washing with large volumes of water, but in general it may be stated that no general method of decontamination appears possible. A secondary but perhaps almost equally important advantage of radioactive material lies in the fact that it would be impossible to develop protective clothing which could be worn by those who were to occupy or traverse the area so contaminated. Here again the difference between radioactive material and such poison gases as mustard gas and lewisite is evident.

C. Radioactive Gas Warfare

3. In the preceding two paragraphs, we have considered only the use of radioactive material from the point of view of contamination of an area. The effectiveness of such contamination arises from the fact that the radioactive substances give off penetrating gamma radiations more or less equivalent in their biological effects to x-rays. A somewhat different use or the radioactive material would depend on the fact that extremely small quantities of certain of the radioactive elements appear to be absorbed in the lungs of animals and produce fatal effects after a period of some weeks. The amounts necessary to produce eventual death under such conditions are extraordinarily small. As little as a total accumulation in the lungs of radioactive material of only 10^{-6} grams would be fatal. This means that if such materials could be kept in the air in the form of a fine dust or smoke

in concentrations as low as two thousandths of a microgram per liter, inhalation of such atmosphere for one hour would be sufficient to establish) a lethal concentration; the material would accumulate in the lungs and the individual would eventually die of the radioactive poison. There is no known way in which such a contaminated individual could be successfully treated once he had thus been exposed. These results in regard to the effect of inhalation of radioactive dust are based on preliminary measures and cannot be considered as final. Nevertheless, they are so striking as to deserve careful consideration.

The particular elements which appear to accumulate in the lungs constitute a major portion of the radioactive byproduct of the piles. While a gas mask with a good filter (the standard combat mask today) would eliminate almost all the radioactive dust from the atmosphere and thus provide protection, two alarming facts must be borne in mind. First, the concentrations we are considering are too low to be seen and the material is odorless and without taste, so it would be difficult to know when to "mask up"; second, even the best masks will allow the penetration of a 0.1 percent of dust if the particle size is about 0.2 microns. Therefore, with concentrations of one microgram per liter (still invisible), an hour's exposure (1000 liters inhalation) might be fatal even with the best mask. On the other hand, there is fortunately one offsetting factor; a dust as fine as 0.2 microns per liter and a concentration of the order of 1-10 micrograms per liter could behave essentially like a gas. The material would not settle but would disperse with winds and temperature differential just as does phosgene. Therefore, all the difficulties of "keeping up concentrations" for more than a few minutes familiar to those concerned with gas warfare would be at hand. It is the long delay in the effect of the material, however, which would be the chief factor in militating against its use as a poison gas.

D. Offensive Uses by the Enemy

4. From the above very brief summary of the essential elements in regard to the use or radioactive material in warfare, the following points seem clear in regard to the possible offensive use of such a weapon:

(a) The use of the material to produce the maximum eventual fatalities would consist in developing ways and means of keeping in suspension in the air in the form of very fine dust or smoke certain of the

> radioactive materials. But it is not an easy problem to devise munitions capable of setting up such clouds of dust or smoke and difficult to keep such clouds from dissipating. Furthermore, the fatalities from radioactive gas warfare would not develop for some weeks, and therefore while the eventual effect on the enemy might be catastrophic, immediate effect on fighting troops would be small.
>
> (b) The use of radioactive material to cause the maximum immediate military effect would appear to lie in the possibility of the contamination of open ground to give sufficiently high radiation over an area to render the area uninhabitable. The chief problem lies in devising suitable munitions which would give a fairly uniform distribution of the radioactive material over the ground chosen for contamination.

The historical record indicates that other physicists than those who produced this memorandum gave thought to the topic of radiological warfare. In 1943, Manhattan Project scientists were not at all certain that the bomb they were attempting to build would actually work. As an alternative, the idea was bandied about of using internal contamination with radionuclides as a weapon. In April of 1943, Enrico Fermi approached Robert Oppenheimer with the idea of harvesting fission products created in a chain-reacting pile and using them to poison the food supply in Germany. Sometime later, Oppenheimer discussed Fermi's proposal with Edward Teller. They concluded that the isotope that offered the "highest promise" was strontium-90, a radioisotope physiologically analogous to calcium which, upon uptake in the human body, is deposited in bone and is slow to be remobilized and eliminated from the system. In a memorandum on the subject, Oppenheimer wrote:

> In this connection I think that we should not attempt a plan unless we can poison food sufficient to kill a half a million men, since there is no doubt that the actual number affected will, because of nonuniform distribution, be much smaller than this.

This statement is chilling. By it, the genocidal mentality in all its cold-hearted, detached viciousness exposes its fangs. It is a perfect example of how this mentality infects the thinking of ordinary people seduced into the enterprise of turning other human beings into casualties. Besides being a physicist, Oppenheimer was a scholar of the humanities, a philosopher, a poet and a mystic. He drew spiritual inspiration for his life from Hindu scriptures. He fancied that he lived a life of doing no harm to other sentient beings. And yet, taking root within the same human psyche that maintained this benign self-image, was a darker vector of thought that in icy detachment designed ways of killing masses of humanity

by hideous means. Such thinking must be recognized as a sickness of the mind. It is a corrupting of a human being's mental/emotional integrity. It objectifies the lives of others, so they can be disposed of like any lesser objects. It is fitting that by his thought and deeds, the weaponeer becomes the first casualty of his genocidal endeavor. He devastates his own interior prior to brutalizing victims on the field of battle.

In his memoirs, Karl Morgan relates information on discussions conducted during World War II about the development of radiological weapons:

> Throughout the war period, Pentagon officials would visit me at ORNL [Oak Ridge National Laboratory] to discuss the feasibility of using fission products as an adjunct to chemical warfare. At the biology, health physics and medical seminars held every two months in one of the Manhattan Project sites — Oak Ridge, Argonne, Los Alamos, Hanford, Berkeley — we considered the question of a lethal fission-product weapon. I visited Dugway, New Mexico, the US chemical warfare testing site. The specialists there agreed with me regarding the military utility of this weapon. It could be dropped on enemy factories with little damage to structures. By excluding from the weapon radionuclides with a half-life greater than eight days, the radiation level would drop to less than 1 percent of its original level in less than two months (Morgan and Peterson).

Morgan's firsthand knowledge of events during the early decades of the nuclear age help clarify events initially hidden from the public under the veil of national security. For instance, he mentions that the notorious release of huge quantities of radioactive iodine-131 from the Hanford Nuclear Reservation in Washington State between 1944 and 1956 was permitted, in part, as a human radiation experiment to investigate fallout dispersal and to determine the effects of radiological warfare on population health;

> The release of 500,000 curies of I-131 (8.04 d [half-life]) into the environment at Hanford was permitted in part to complement the chemical warfare studies of the effects on the neighboring population downwind — and, of course, away from the Hanford community. The rationale was the need to test their instruments in calibrating the fallout pattern. The exposed "expendables" — primarily Native Americans — were not told of this until 1990, some 45 years after the exposures. Recent studies by one of my former Georgia Tech students, J.E. Till, revealed that doses to the thyroid reached hundreds of roentgens. Not surprisingly, a high incidence of thyroid carcinoma has appeared in this population (Morgan and Peterson).

Radiological warfare was never pursued during the Second World War. The idea, however, was never abandoned. Rather, it became subsumed within the broader topic of nuclear weapon development and deployment, since radiological warfare was a necessary consequence of warfare with nuclear weapons. By the end of 1946, five atomic bombs had been detonated. These were the Trinity test shot at Alamogordo, New Mexico, in July 1945, the obliteration of Hiroshima followed by that of Nagasaki six weeks later, and the test shots Able and Baker of Operation Crossroads in the Marshall Islands in July 1946. These detonations served, among other things, as giant radiation experiments. Scientists used these opportunities to gather a wealth of information on the radiological characteristics of the new weapons. What was discovered was shocking. Manhattan Project physicists had made significant miscalculations on the radiological aftermath of massive nuclear fission events, vastly underestimating the radiological consequences of their creation.

Three of these oversights were to change, forever, life on planet Earth.

As originally conceived, the primary radiological hazard from an atomic bomb was thought to be the instantaneous burst of neutron and gamma radiation at the moment of detonation. Manhattan Project physicists estimated, however, that this lethal barrage would not extend beyond the zone where 100% of the exposed victims would first be killed by traditional blast effects. Beyond this perimeter, the major radiological hazard was thought to be from gamma and beta emissions from the atomized components of the weapon itself that had acquired radioactivity during the nuclear chain reaction. What was not anticipated was the massive amount of radioactive material created in the fireball as a result of neutron activation of elements in the soil, air and water. Born in the nuclear inferno were tons upon tons of radioactive material that vastly compounded the radiological aftereffect of a bomb's explosion.

A second discovery was equally startling. It was so significant that it reshaped human thinking, giving birth to the ecological consciousness that arose during the second half of the twentieth century. Weapon designers originally thought that, as the radioisotopes released in an atomic explosion moved through the biosphere away from ground zero, they would soon dissipate to insignificant concentrations and settle harmlessly in the environment. The error of this notion came to light just months after the Trinity test blast. In Rochester, New York, film inspectors at Eastman Kodak began noticing imperfections on unexposed X-ray film. Chemical analysis revealed these flaws to be caused by the radioactive decay of an isotope with a 32 day half-life. Further, promethium was discovered to be the decay product of this isotope, an element not naturally found in the Earth's crust. From this information it was deduced that cerium-140 from the soil of New Mexico had been transformed by the Trinity blast into radioactive cerium-141, ejected into the atmosphere

and carried by winds across the country. Scavenged by rain, a significant concentration of this contaminant was deposited in the Wabash and Iowa Rivers, where it was taken up by two paper mills and incorporated into strawboard used in the packaging for X-ray film. This discovery demonstrated the long-range transport of radionuclides and the ability of precipitation to scavenge this material from the air and concentrate it in "hotspots." Contamination of large sectors of the Earth away from ground zero was proven to be an inescapable byproduct of the detonation of atomic weapons. "Fallout" was a new fact of life.

A third, unanticipated, and most significant radiological consequence of nuclear weapons was more obscure and took over a decade to be understood. Its implications for the future of life on Earth have yet to be fully ascertained. The scientific team developing the bomb at Los Alamos believed that the chief health hazard of a nuclear weapon was radiation received to the body's exterior in the form of gamma and beta rays. Although the hazards of ingesting radium had been known since the 1920's, the degree of harm from ingesting bomb-generated radioactivity was judged to be minimal due to the anticipated environmental dispersal. What was never anticipated was that living systems would act as bio-accumulators of radioactivity. Plants accumulate lingering environmental radioactivity in their cells. These are a food source for foraging creatures who, by eating contaminated plants, accumulate far greater concentrations of radioactivity within the interior of their cells. These creatures in turn are eaten by other creatures and so it goes along the food chain. The creatures at the highest end of the food chain end up accumulating the highest concentrations of radionuclides. By this process, the human body becomes a significant repository of environmentally dispersed radioactivity.

As Cold War tensions accelerated aboveground weapon testing during the 1950's, the phenomenon of internal contamination from the ingestion, inhalation and absorption of fallout became increasingly well understood. In 1957, a fire broke out in the nuclear facility at Windscale in Great Britain. In response, researchers undertook environmental monitoring of the surrounding area. They discovered that sphagnum moss, other mosses, lichen and other types of vegetation had absorbed significant quantities of cesium and other radionuclides. The source of this contamination was originally attributed to the Windscale accident. But curiously, it was discovered that the concentration of radionuclides did not vary in distance or direction from the facility. Further analysis revealed that the actual source of radionuclides in the vegetation under investigation was from global fallout. The hypothesis soon followed that animals feeding on the contaminated plants would concentrate radionuclides in their tissues. The lichen-caribou-human food chain was subsequently investigated and proved to be a source of significant human contamination to circumpolar native peoples living in extreme northern latitudes. As many as 160,000 North American Indians, Inuit in Canada and Alaska, Lapps from northern Sweden, Norway and

Finland, and northern Asiatic natives throughout the USSR showed evidence of contamination by radioactive cesium and strontium released into the biosphere from atmospheric testing of nuclear weapons. Weapon testing in the continental United States created a similar pathway of internal contamination. Weapon tests at the Nevada Test Site released fallout that settled in the environment downwind. In turn, grazing diary cattle accumulated quantities of the dispersed radioactivity, most significantly iodine-131 and strontium-90, and passed it along to humans through their milk. The resulting dairy products were the vehicle for the deposition of biologically significant quantities of radioactivity into the bodies of local children.

As the radiological hazards of fallout began to be understood, the idea of using bomb-generated radiation for military purposes came under serious consideration. The incident that ignited the imagination of military strategists was Shot Baker of Operation Crossroads in 1946. The bomb for this test was a plutonium bomb similar to the one that destroyed Nagasaki, but as an experiment, weapon designers encased the plutonium core in an outer shell of uranium-238 with the expectation of enhancing the radiological effect. Also as an experiment, the bomb was detonated 90 feet underwater in the lagoon of the Bikini atoll. The result was a radiological catastrophe. Hundreds of thousands of tons of radioactive seawater were ejected skyward, and the mist that drifted down after the blast deposited an atom-thin layer of plutonium over the entire test site and aboard the naval vessels participating in the exercise. The once pristine tropical paradise was instantaneously transformed into a radiological nightmare. Radiation readings of 1000 roentgens per hour were recorded on a nearby island in the immediate aftermath of the blast. Shortly after detonation, the level of radioactivity distributed across the lagoon was equivalent to a billion grams of radium. During the following days, sailors participating in cleanup exercises began accumulating significant dosages. As the teams of radiation monitors began to fully comprehend the seriousness of the potential health consequences, they recommended to the fleet commanders that crews be ordered below deck for periods of time to shield them and minimize exposure. This protective measure did not work as planned. Contaminated seawater, drawn from the lagoon and circulated through the ships' extensive network of pipes to operate onboard plumbing systems, continued to irradiate sailors living below deck. To avert a potential scourge of radiation injury, Shot Charlie, the third planned detonation of Operation Crossroads was scrapped, and the fleet fled the lagoon, evacuating the area and returning to the mainland US.

The radiological mess created at Bikini did not escape the notice of military strategists. As a result of Shot Baker, they conceived the idea that weapons could be intentionally created to cause similar turmoil in enemy territory. Further, they witnessed firsthand the strategic advantage of detonating an atomic bomb underwater adjacent to enemy ter-

ritory and relying on the radioactive mist that was created to serve as a means of terrorizing the enemy. Some military thinkers proposed that radiological warfare could actually evolve into a more humane method of conducting warfare. To their way of thinking, by contaminating enemy lands and making areas uninhabitable, the ability of the enemy to conduct military operations could be disrupted and their forced exodus would avert the anticipated toll of death and injury from actual combat.

Dr. Joseph Hamilton, a physician on the medical staff at Los Alamos where the atomic bomb was designed, saw evidence from Shot Baker that dispersed radioactivity could be used successfully as a strategic weapon against cities and the enemy's food supplies. Besides creating social chaos, the ingestion of contaminated food could debilitate enemy populations, causing slow, progressive injuries and pathologies. To explore the medical effects of this novel approach to warfare, Hamilton proposed an experiment whereby terminal leukemia patients would be administered, via inhalation, raw fission products. He freely admitted that his proposal harbored "a little of the Buchenwald touch" (Herken).

In response to a Freedom of Information Act request filed in 1995, the Associated Press acquired heavily censored documents in 2007 outlining the Army's early efforts to make radiological warfare a reality (Burns). Starting in 1948 and continuing to at least 1954, the Army was investigating this "new concept of warfare" as a means of contaminating enemy military bases, factories and troop formations. In a memo dated December 16, the priorities of weapon development were outlined:

> 1 — Weapons to contaminate "populated or otherwise critical areas for long periods of time."
> 2 — Munitions combining high explosives with radioactive material "to accomplish physical damage and radioactive contamination simultaneously."
> 3 — Air and/or surface weapons that would spread contamination across an area to be evacuated, thereby rendering it unusable by enemy forces (Burns).

Of considerable interest is the fourth ranked priority: "munitions for attack on individuals" using radioactive agents for which there is "no means of therapy" (Burns). What the Army was contemplating was to use radioactive material as a weapon of assassination. According to the document acquired by the Associated Press: "This class of munitions is proposed for use by secret agents or subversive units for lethal attacks against small groups of important individuals, e.g., during meetings of civilian or military leaders." Continuing to summarize the memo, Burns reports as follows:

> The Dec. 16, 1948, memo said a lethal attack against individuals using radiological material should be done in a way that makes it impossible to trace the US government's involvement, a concept known as "plausible deniability" that is central to US covert actions.
>
> "The source of the munition, the fact that an attack has been made, and the kind of attack should not be determinable, if possible," it said. "The munition should be inconspicuous and readily transportable."
>
> Radioactive agents were thought to be ideal for this use, the document said, because of their high toxicity and the fact that the targeted individuals could not smell, taste or otherwise sense the attack.
>
> "It should be possible, for example, to develop a very small munition which could function unnoticeably and which would set up an invisible, yet highly lethal concentration in a room, with the effects noticeable only well after the time of attack," it said.
>
> "The time for lethal effects could, it is believed, be controlled within limits by the amount of radioactive agent dispersed. The toxicities are such that should relatively high concentrations be required for early lethal effects, on a weight basis, even such concentrations may be found practicable."

The method of assassination came into public awareness in 2006 when Kremlin critic Alexander Litvinenko was poisoned with polonium-210 while in London. Those responsible for the murder have never been identified.

In May 1948, the Atomic Energy Commission and the Department of Defense sponsored a joint panel to study the offensive feasibility and defensive requirements of "Rad War." The committee, chaired by W.A. Noyes of the University of Rochester, consisted of both civilian experts and government officials. At their first meeting, a plan was devised for pursuing three avenues of research. (1) The Army Chemical Corp's Toxicity Laboratory at the University of Chicago was assigned the task of conducting biological studies on the effects of radiation and radioactive materials. (2) The Atomic Energy Commission (AEC) was given responsibility for investigating options for producing radioactive materials suitable for radiological warfare. (3) The Chemical Corp assumed responsibility for studying RW munitions and other delivery devices.

These research initiatives eventually led to actual field tests. The first two tests were conducted at Oak Ridge, Tennessee. In these, sealed radioactive sources were set out in an

open field in order to devise means of accurately measuring radiation levels in the environment and to help predict the effectiveness of radiological weapons. At the completion of these experiments, the sealed sources were returned to the lab without causing any environmental contamination. Actual environmental releases soon followed. Between 1949 and 1952, the Chemical Corps conducted 65 field tests at the Army's Dugway Proving Ground in Utah. Fifteen of these tests involved the explosion of experimental radiological warfare bombs. In total, 13,000 curies of tantalum-182, with a half-life of 117 days, was released into the environment in the form of dust, small particles, and pellets. These tests remained classified information until 1974 and did not receive much public attention until 1993 when the Department of Energy began releasing voluminous material on the government's involvement in human radiation experiments and intentional releases of radioactivity into the environment.

In 1952, the Chemical Corps began making plans to expand the radiological warfare program. A test was devised for the following year involving the release of 100,000 curies into the environment. Larger tests were to follow. These field experiments were never performed, however. They were canceled along with the entire radiological warfare program. According to the Advisory Committee On Human Radiation Experiments, there were two possible reasons for the program's cancellation (Department of Energy, February 1995). First, the expanded phase of the program would have required the construction of expensive new production facilities which were incompatible with budget cuts at the end of the Korean War. Second, few outside the Chemical Corps were convinced that the program satisfied any military need. As a consequence, further research in radiological warfare was shelved. Over the next decade, the study of radiation as a possible weapon of war merged with the nation's nuclear weapons program. Experiments were performed during atmospheric weapon testing and data was collected about the radiological aftermath of these detonations. Within this paradigm, all possible scenarios for radiological warfare came to be envisioned within the context of waging nuclear war.

No great mystery exists as to why the radiological warfare program of the 1940s and 50s was terminated. The development of a successful radiological weapon as distinct from a nuclear weapon would have been contingent upon solving a number of fundamental problems. By its very nature, radiological warfare is a dirty method of combat that befouls the environment. A radiological weapon, in whatever form it took, would deliver a contained volume of radioactive material to the site of release and then disperse it in atom-sized packets that would be forever irretrievable. The contaminated area would become blanketed by an invisible, submicroscopic layer of deathly threat. Until radioactive decay sufficiently reduced the lethality, which depending upon which radionuclides were involved might take decades, centuries or millennia, or until the affected area was decontaminated,

which might be impossible, everything in the target area would be spoiled and made useless for human purposes. Soil and dust stirred up into the air by weather or human activity would make the very act of breathing a risk to health. The water would be poisoned. The land would be poisoned. Agricultural activities would have to be restricted or entirely curtailed. Plants might readily absorb some of the radionuclides and be rendered inedible. Livestock, if they managed to survive, would be similarly tainted. With radioactivity clinging to everything and settling in the tiny crevices of wood, metal, brick, concrete, and asphalt, all artifacts of human culture would be transformed into a radiation hazard. Cleanup, a misnomer, could reduce the concentration of dispersed radioactivity but never entirely eliminate it. Radionuclides would persist in the environment and present an ongoing threat. Those that failed to become lodged in one place would continue to randomly circulate throughout the environment. The wind would blow them about. Precipitation would cause them to move through the local watershed. Adhering to the soles of people's shoes or to their clothes, radionuclides would be transported by human activity into the interior of buildings and homes. Sticking to the tires of vehicles, they would be carried from neighborhood to neighborhood, village to village. The ubiquity of the dispersed material would make it insidious. As with Pandora's Box, once the evils and miseries were released into the world, they could never be regathered again.

Radiological weapons would be weapons of indiscriminate effect. Within the area in which they were deployed, all living things would be potential casualties. Like chemical and biological weapons, the dispersal of radioactivity could not be targeted only at enemy combatants while leaving unarmed civilians, women, and children unharmed. Due to differences between one person and the next, exposure and absorbed dosage would vary in unpredictable ways. Depending on dosage, death or debilitating injury might take from hours to days to years. The types of injury would also be variable. Some people might be killed or incapacitated rapidly due to acute exposure. Others might be temporarily sickened. Still others might experience a variety of chronic conditions which they would suffer from the rest of their lives. Radiation-induced illnesses, such as cancer or genetic defects in the next generation, might take decades to manifest.

The full spectrum of possible injury from radiological weapons would depend on the menacing ingenuity of the weapon designers and the types of radionuclides they incorporated into their creations. Due to the wide range of differences among radionuclides in their physical properties and biological effects, weaponeers would have a palette of deadly isotopes that they could mix and match to create whatever effects they desired. Indiscriminate, rapid incapacitation could be achieved by blanketing an area with heavy concentrations of radionuclides that emitted gamma rays (radiation similar to x-rays but more energetic) that would irradiate the body from the outside, penetrate through it, and

cause massive disruption to the molecular integrity of the organism. This type of exposure might induce acute radiation syndrome that, depending on dosage, could quickly sicken a victim, either mildly or severely, and lead to recovery within a short period of time, prolonged illness and debilitation, or death. As an alternative, radionuclides might be chosen for a weapon that could only cause harm through internal contamination. By this vector, the radionuclide(s) would have to be delivered in such a way as to be inhaled, ingested or otherwise absorbed into the body of an enemy before causing prostration. This alternative is more akin to chemical warfare. Dosage would vary throughout the exposed population and some variability would most likely exist in the types and degrees of injury. Internal contamination would have the capacity to sicken large segments of the targeted population with chronic or terminal diseases and essentially ruin their lives. Widespread genetic damage might also be induced, altering the gene pool of the victimized group and injuring the progeny of the next generation(s).

The objective of deploying radiological weapons would be to contaminate people and the environment in which they dwelt. In response, to mitigate the effects of an attack with these weapons, a population sufficiently sophisticated to recognize that it was under siege by radiation would take precautions to minimize exposure. Makeshift masks could be fabricated from fabric or paper to minimize an inhalation hazard. Contaminated surface water could be filtered or distilled before ingestion. Livestock could be taken off contaminated pasture and fed stored fodder if available. Meat from animals which had grazed on contaminated land could be avoided. Produce dusted by contamination could be thoroughly washed or the more surface layers removed. Plants grown in contaminated soil could be avoided or tested and evaluated for safety prior to ingestion. The final option for a people whose environment had been ruined would be migration to less compromised lands. Such forced migration might actually be a goal of radiological warfare, herding populations for political and military advantage or for the purpose of conquering lands rich in mineral reserves.

Radiological warfare is a particularly nefarious form of psychological warfare. Radiological weapons are weapons of terror. Radioactivity is invisible, undetectable without sophisticated equipment, and most often causes delayed injury and illness. Without sufficient training and knowledge, people will panic at the very thought that radiation has been released within their vicinity. Overwhelming anguish will consume their thoughts as to whether they have been exposed, the extent of their exposure, the potential illnesses growing inside them, and so forth. Radiophobia, well documented after radiation accidents, will induce a wide range of psychosomatic illnesses that are ruinous to the quality of people's lives. A whole population so traumatized may descend into chaos, the social fabric irreparably torn. The rule of law may collapse into anarchy or call forth authoritarian control by

government to suppress social unrest.

The United States restrained itself during the Korean War and the War in Vietnam. Weapons were never fielded that released radioactivity in the midst of enemy populations. Military strategists, however, never fully abandoned the idea of using radioactivity as a weapon. Radioactivity's place in warfare was seen as an enhancement and extension of nuclear war. As a consequence, the military investigated methods for enhancing the radiological effects of atomic and thermonuclear weapons. Military planners anticipated that a likely scenario for future conflict might include battles in Europe against an advancing, well armored Soviet army. In their vision, fending off such an attack required a new tactical weapon that maximized battlefield casualties, stopped tanks, but created minimum damage to the surrounding densely populated European homeland. The notorious neutron bomb was born from this thinking.

In the detonation of a hydrogen bomb, most of the liberated energy is derived from the fusion of deuterium and tritium, the heavy isotopes of hydrogen. To initiate this fusion reaction, a chemical high explosive is detonated which in turn implodes a small core of fissionable material. This relatively small atomic bomb creates the heat and pressure necessary to compress a surrounding layer of hydrogen isotopes and cause the atoms to fuse together to produce helium. Released in the process is a colossal quantity of energy and a barrage of high-speed neutrons. In the typical hydrogen bomb, an outer casing of fissionable uranium surrounds the hydrogen. The neutrons released in the fusion reaction collide with the nuclei of this uranium and induce it to fission. This further compounds the explosion creating more blast, heat, radiation and fallout.

Weapon designers hit upon an idea for modifying this basic design so as to minimize the blast while maximizing the radiation effects. By eliminating the outer jacket of uranium, they created a relatively small-yielding fusion weapon that delivered blast and heat effects to a confined area, as small as a few hundred yards in radius, that produced a minimum of fallout, but liberated an enormous barrage of neutrons. This volley of neutrons would reach well beyond the circle destroyed by the explosion, irradiating all human beings in the area, causing rapid debilitation or death. With the capacity to pass freely through the walls of armored vehicles, the salvo of neutrons provided the additional bonus of enfeebling enemy tank crews within minutes. Since this weapon was specifically designed to minimize the production of fission products, it was anticipated that friendly troops could move into the area without fear of radiation after a delay of only 48 hours and occupy the infrastructure that had been spared by the minimal blast effects. The first successful test of a neutron bomb occurred in 1962 after the Soviet Union broke the nuclear test moratorium. During the mid-1970s while Jimmy Carter was president, neutron bombs were installed on

Lance missiles and eight-inch howitzer cannon shells.

In response to a US plan to stockpile the neutron bomb in Europe, people in many countries poured into the streets in protest. The enhanced radiation device, designed to limit property damage while killing or incapacitating a maximum number of people, came to symbolize the triumphant culmination of materialism. Nikita Khrushchev, Premier of the Soviet Union at the time, characterized the neutron bomb as the epitome of the bestial ethics of Western imperialism: a weapon crafted to annihilate masses of humanity while preserving all the riches of the world. Many feared that the neutron bomb was destabilizing, that military planners would not be deterred from employing the weapon in combat and that its use would lead to the outbreak of total nuclear war. Europeans, occupying land anticipated as being ground zero in a future conflict, voiced the strongest opposition to the neutron bomb and prevented the stockpiling of the weapon within their homelands. Despite widespread opposition to this device, it is believed that a version of the neutron bomb is still part of the current US arsenal.

If the imagination falters when trying to visualize the consequences of radiological warfare or the radiological aftermath of nuclear war, just look to Chernobyl. Chernobyl was the oracle of our age, prophesying what awaits the world should nuclear/radiological warfare erupt: casualties, mass evacuations, an epidemic of acute and chronic illnesses, an epidemic of psychological disorders, alterations of the gene pool, an increase in congenital defects, contamination of the food supply, long-term contamination of the environment, and unanticipated wide-ranging effects to the health of populations living at great distances from the source of the radiation release.

In the wake of the Chernobyl disaster, the entire world became cognizant of the vulnerability of the human food supply to radioactive contamination. Within 24 to 36 hours after the massive venting of radionuclides, a buildup of radioactivity began being detected on samples of forage grasses and leafy vegetables in open fields downwind. Local farmers, unaware that their garden crops were contaminated with hazardous concentrations of radionuclides, continued to consume salad greens, cabbages, spinach and broccoli. Uptake of iodine-131 in the early weeks after the accident was the primary environmental hazard and was responsible for the pandemic of thyroid abnormalities that followed. In addition, cesium isotopes were discovered in alarming concentrations in milk, cereals and a number of different fruits and vegetables. The contamination was not confined to the Ukraine. West German powdered milk, Italian wheat, Irish potatoes, and Dutch butter were all found to be contaminated. Milk befouled by radioiodine and cesium was destroyed in Poland, Hungary, Austria and Sweden. Vegetable crops were destroyed in parts of France,

Greece and Italy. Even the year's tea crop from Turkey evidenced measurable levels of Chernobyl fallout. As much as 60 to 70 per cent of the anticipated future health problems resulting from the accident are expected to develop as a result of the consumption of contaminated agricultural products.

As with most events involving the dispersal of radioactivity into the environment, the ultimate health consequences to the exposed population will never be fully known. Trends, however, have been observed and published that serve as predictors of the malignancies creeping through the population from internal contamination. Within a few years of the accident, evidence began emerging of an epidemic of pediatric thyroid cancers. In one area, where only seven cases were reported between 1976 and 1985, representing a rate of one case per million people, the number jumped to 233 cases between 1990 and 1993, representing a rate of 36 cases per million inhabitants (Kazakov *et al.*; Nikiforov *et al.*). The World Health Organization reported that in the area of Gomel, which is the region of Belarus directly north of Chernobyl, the rate of thyroid cancer in children reached more than 100 cases per million. The British Medical Journal reported in 1995 that the rate of thyroid cancer in Ukraine and Belarus was 200 times higher than normal. The British Imperial Cancer Research Fund found a 500% increase in thyroid cancers among Ukrainian children between 1986 and 1993 (LaForge).

The frequency of congenital defects progressively increased in the years following the accident. According to a 1995 report published in Belarus by the Ministry for Emergencies and Population Protection from the Chernobyl Catastrophe, the rate of congenital defects throughout the Republic jumped from 12.5 per 1,000 births in 1985 to 17.7 per 1,000 births in 1994. The types of defects observed were infants born with deformed arms and legs or extra fingers and toes. From a study sponsored by the World Health Organization, it was revealed that children *in utero* at the time in highly contaminated areas manifested a greater incidence of mental retardation, behavioral disorders and emotional problems than a similar population of children *in utero* at the time in uncontaminated areas. (The study cautioned that a link between these problems and the accident could not be conclusively proven.) Other studies conclusively proved that between 1987 and 1995 the incidence of most classes of childhood disease increased among children listed in the Chernobyl registry (Lomat *et al.*). There were observable increases in 1995 in the incidence of thyroid cancer and other thyroid abnormalities, endocrine and dermatological diseases, diseases of the digestive organs, and mental disorders. By 1990, an increase was noticed in autoimmune thyroiditis as well as an inordinately high incidence of chronic tonsilitis and adenoiditis. Among the entire population, the highest rates of hematopoietic tissue diseases appeared in children born after the accident to parents who had been irradiated (Lomat *et al.*).

For countries where good data were available both for exposure to Chernobyl fallout and incidences of childhood leukemia, harm to children *in utero* at the time of the accident and its immediate aftermath was discovered. In Scotland, Greece, the United States, Germany and Wales, studies confirmed that the cohort of children exposed in the wombs of their mothers to radionuclides released from Chernobyl suffered significantly increased incidences of leukemia in their first year of life. Owing to the accurate data in Scotland and Wales, calculations could be done comparing exposure to incidences of leukemia which revealed that the presently accepted models of risk for radiation-induced leukemia underestimate the true hazard by a factor of between 100 and 2,000-fold. The danger to the public health from such inaccurate standards of safety for internal exposure cannot be overemphasized. During the period of worst fallout from Chernobyl, the National Radiological Protection Board of Great Britain continued to advise the public that levels of exposure were too low to impact health and that it was perfectly safe to consume water from open-air sources, fresh meat and produce, milk and other dairy products.

The great unknown of the Chernobyl catastrophe is the overall lifetime consequences to the health of the exposed populations, those dwelling in proximity to the accident and those all over the world subjected unawares to fallout. It will be decades, at the very least, before the medical impact from the ingestion of foodstuffs contaminated by cesium and strontium isotopes becomes apparent. A high incidence of a variety of cancers, compromises in immune system functioning, life-span shortening, genetic defects in future generations, and so on are all potential health problems that will slowly begin to manifest themselves with the passage of time. How much of this will be camouflaged by normal disease processes and other relevant population dynamics and how much will eventually come to light is the challenge facing future researchers trying to assess the widespread impact of internal contamination from the accident.

Psychologists might call it projection. Conspiracy theorists would call it psy-ops, a psychological operation. However one wishes to characterize the phenomenon, it is an amazing coincidence that spokesmen for the government of the United States began openly talking about the terrorist threat of a bomb laced with radioactive material just at the time when the US began contaminating foreign countries with depleted uranium. While waging radiological warfare without provocation, the United States immediately reinvented itself as the potential victim of terrorists planning to contaminate our homeland with radioactivity.

Radiation Dispersal Devices (RDD), known in the vernacular as "dirty bombs," are the poor man's ticket of entry into radiological warfare. RDDs are conventional explosives packaged with any available type of radioactive material. Upon detonation, the bomb dis-

perses an atom thin layer of contamination into the immediate environment of the blast. The extent of the befouling will depend on which radionuclides are included in the bomb, their quantity, the size of the explosion and the meteorological conditions during and after the event. Detonated in a busy urban setting, a dirty bomb packaged with a radionuclide such as cobalt-60, a beta- and gamma-emitter, might produce mass casualties through external exposure. Skin burns, acute radiation syndrome and death would be possible outcomes. A bomb containing radionuclides such as plutonium-238, strontium-90 or uranium/non-depleted uranium would more likely produce a hazard from internal contamination, threatening victims with a future epidemic of cancers. A bomb spreading hospital waste from a nuclear medicine department may present no physical hazard whatsoever while, nevertheless, igniting widespread panic.

Dirty bombs are instruments of terror. They are weapons of mass disruption, mass distraction and mass dislocation. Their purpose is to cause harm to human health, induce panic, prevent access to a contaminated areas and greatly complicate emergency response. Given that radiation is invisible, little understood by the layman and capable of producing birth defects and malignancies way into the future, people once notified that a dirty bomb had been set off would flee in panic. Unable to assess the level of exposure to themselves or their loved ones and uncertain as to the likelihood of future health concerns, many people will be overwhelmed by anguish and debilitating anxiety. If the RDD were detonated in an urban setting, cleanup may be long and laborious, and caution might persuade people to resist resettlement. Reassuring pronouncements from public officials would likely be met with distrust. Jobs would be abandoned, services discontinued, healthcare systems overwhelmed, and crime would flourish. With the social order in chaos, martial law is a logical consequence. For Americans to catch a glimpse of the psychological distress produced by radiation dispersal devices, they should look to Iraq. It is now common for Iraqi mothers, at the moment of giving birth, to ask their obstetricians not "Is it a boy or a girl?" but "Is it normal?"

That terrorists might resort to acts of radiological warfare is a realistic possibility. According to the International Atomic Energy Agency's Illicit Trafficking Database (Orlov), there were, as of December 2003, 540 confirmed incidents involving the illegal acquisition, smuggling or selling of nuclear or radioactive material. Included in the database were an additional 344 incidents that remain unconfirmed. Of the confirmed incidents, 182 involved nuclear material. Of these, 18 involved highly enriched uranium (HEU) or plutonium but in quantities too small to fabricate a nuclear weapon. A few cases involved more than a kilogram of HEU and one case involved 0.3 kg of plutonium. The remaining cases involved less than 1% to 2% of the quantity of material needed to construct a nuclear bomb. Of the remaining 174 incidents involving nuclear material, these involved lower-

grade materials such as low-enriched uranium in the form of nuclear reactor fuel pellets, natural uranium in a variety of forms and purity, depleted uranium, and thorium in various forms including ore. Within the database, there were 335 confirmed incidents involving radioactive material other than nuclear material. In most cases, the trafficked materials were sealed radioactive sources. There were some incidents involving unsealed sources, material contaminated with radioactivity, or contaminated scrap metal. Given this array of material appearing on the black market, it is highly credible that terrorists could acquire sufficient radioactive material to create a mass casualty event or one producing extreme panic and chaos.

Much talk has been given to the subject of securing our borders to avert terrorist infiltration with weapons of mass destruction. What receives scant attention is that plenty of nuclear and radioactive material is present within our borders that could be acquired, either legally or illegally, for the fabrication of a radiation dispersal device. Throughout the United States, radioactive sources are used for a variety of commercial applications. A citizen intent on dispersing radioactivity, alone or allied with foreign or domestic terrorists, could establish a legitimate business and go about acquiring radioactive sources legally. By this means, hazardous quantities of dangerous radioisotopes could be collected for diversion to a devastating dirty bomb. As an alternative to legitimate acquisition, radioactive sources could be acquired by theft. Due to the ubiquity of radioactive sources throughout the nation and the fact that these hazardous materials are often not adequately guarded, thieves with only a rudimentary knowledge of radiation safety could safely steal all that would be required to produce a mass casualty event.

Worldwide, there are millions of radioactive sources. They are found in a variety of commercial applications in medicine, industry and research. In the hands of terrorists, many of these sources could be used to induce panic. Realistically, however, the number of radioactive sources that could produce injury and disease to a large number of people is much smaller. This point is clarified by Ferguson *et al.* in *Commercial Radioactive Sources: Surveying the Security Risks*:

> Only a small fraction of the millions of commercial radioactive sources used globally, perhaps several tens of thousands, pose inherently high security risks because of their portability, dispersibility and higher levels of radioactivity. As a rule, these more dangerous commercial sources are those containing relatively large amounts of radioactivity (typically more than a few curies worth of radioactivity, or in terms of mass, roughly a gram or more of radioactive material) of seven reactor-produced radioisotopes: americium-241, californium-252, cesium-137, cobalt-60, iridium-192, plutonium-238 and

> strontium-90. Some of these isotopes (americium-241, californium-252 and plutonium-238) would only pose internal health hazards by means of ingestion or inhalation, while the others would present both internal and external health hazards because the emitted ionizing radiation could penetrate the dead outer layer of human skin.

Potentially devastating quantities of certain high-risk radioisotopes are found in a number of commercial applications. Teletherapy machines, used in the treatment of cancer, contain between 1,350 and 27,000 curies of cobalt-60 or 13,700 curies of cesium-137. Worldwide, there are more than 10,000 of these machines, located mostly in hospitals and medical clinics. Irradiation facilities, of which perhaps 300 exist globally, use gamma radiation for food preservation and sterilization of such things as medical supplies. These employ a radiation source of either cobalt-60 or cesium-137 in quantities of between 2,700 and 11,000,000 curies. Scattered along Russia's northern coastline are hundreds of radioisotope thermoelectric generators, used for power supplies in remote locations. Each unit contains strontium-90 at levels between 30,000 and 300,000 curies. Portable industrial radiography units, used to check for flaws in welds and to perform a variety of nondestructive testing procedures, contain between three and 250 curies of iridium-192.

The vast majority of radiation sources in use in the public domain typically contain only a small fraction of a curie of radioactivity. In themselves, these pose little or no hazard. However, the facilities where these are manufactured are centers that may be in possession of significant quantities of radioactive materials. Manufacturers of radioactive sources or equipment manufacturers that use these sources to produce a variety of gauges and detectors may have on their premises quantities of radioisotopes that would be an inviting target for someone interested in acquiring the makings of a dirty bomb. In addition, there are businesses dedicated to the maintenance, repair and recycling of equipment containing radioactive sources, any of which might be a lucrative target for plunder.

A nuclear power plant is the prize target for terrorists intent on dispersing radioactive material into the environment and initiating social chaos. A witch's brew of radioisotopes resides in huge quantities in the core of each nuclear reactor and in the on-site cooling ponds and storage caskets for spent nuclear fuel. If a dedicated team of terrorists could commandeer a nuclear power plant and vent a portion of this material into the atmosphere with conventional explosives, an unprecedented catastrophe could be created, wreaking havoc on the population of an entire nation or a whole geographical region.

One nation terrorizing the population of another with radioactivity commenced in 1991. The history books will forever record that the United States initiated radiological warfare during its first war in Iraq. The tenuous, undeclared moratorium among nations

of using radioactivity as a weapon was contravened when the US began fielding munitions made of depleted uranium. A taboo, in place to protect humanity from itself, was violated. This betrayal of humankind was precedent-setting, putting the world on notice that the United States would not hesitate to deposit its radioactive waste in the territory of its adversaries and inside the bodies of its enemies.

In the movie *2001: A Space Odyssey*, Stanley Kubrick created a now-famous scene that suggests the origin of the uranium/depleted uranium weapons of today. A pre-human anthropoid, emaciated and hungry, stumbles upon the skeletal remains of a wildebeest-type animal. Hoping to scavenge a morsel of meat, he rummages through the bones. Finding nothing, despondent, he picks up a bone and haphazardly tosses it down again, creating a clatter against the other bones. In curiosity, he picks up the bone a second time and, hesitatingly, strikes the bones again, this time not letting go. Again, he lifts his hand and brings down the bone. And again with more force. And again, lifting his arm wildly over his head and thrashing the carcass with all his might. While in the midst of this frenzied enterprise, the light of discovery dawns in his eyes and empowerment fills his stature. His primitive primate brain has discovered the first tool, a club, a weapon by which to kill, which represents the vanguard of all future human destructiveness.

Though pure speculation, a scene not unlike that of the famished anthropoid must have taken place in the brain of some low-level defense analyst at his cubicle in the basement of the Pentagon. Upon his cluttered desk, a file spilling over with reports of the increasingly unmanageable inventory of the nation's uranium waste being generated as a byproduct of the nuclear fuel enrichment process. A second file, impossible to keep separate from the first, overflowing with studies of the feasibility of developing new alloys for antitank munitions and plating for armored vehicles. In his mental fog, prior to the morning's first cup of coffee, his bureaucratic mind teeter-tottered back and forth between the items on his To Do list. Uranium waste. Tanks. Uranium waste. Artillery shells. Uranium waste. Dense Metal. Uranium. Munitions. Uranium. Munitions. Uranium Munitions! There in the basement, in a eureka moment, pregnant with the promise of a pay upgrade, his primitive brain foresaw the possibility of transforming the nation's uranium waste into ordnance that would render an enemy's armor obsolete while providing an excuse for disposing of our radioactive waste on foreign lands. A sweet solution to two labyrinthine dilemmas.

Uranium/depleted uranium munitions are cunning and deceitful weapons. Justification for their use is based on their amazing ability to penetrate and destroy armored vehicles and other hardened targets. But while fulfilling this overt mission, they simultaneously carry out a more covert agenda: radiological contamination of enemy populations.

This is radiological warfare elevated to a fine art, the fulfillment of a half century of study, subtle and sophisticated.

After the destruction of Hiroshima and Nagasaki, a group of scientists and medical personnel from the Manhattan Project were dispatched to Japan to study the effects of the atomic bomb. While there, they had the opportunity to exchange information with members of a counterpart committee assembled by the Japanese government. The Japanese committee was under the direction of Masao Tsuzuki, a surgeon and teacher at Tokyo Imperial University, who had been one of the first to conduct a survey of the rubble that had once been Hiroshima. Before the war, Tsuzuki had studied in the United States and had published a paper on the acute effects of ionizing radiation. During this meeting, Tsuzuki had an interesting exchange with one of the members of the American team. The incident is recounted by Barton Hacker in his book *The Dragon's Tail*: "A member of the Manhattan Project Atomic Bomb Investigating Group met him [Tsuzuki] in Tokyo and saw a copy of his 20-year-old study. [Said the team member:] 'When I handed the thesis back to him, he slapped me on the knee and said, 'Ah, but the Americans — they are wonderful. It has remained for them to conduct the human experiment'" (Hacker 1987).

There is truth in Tsuzuki's bitter, biting observation. The United States has a track record of conducting human radiation experiments and is conducting them to this day. Hiroshima, destroyed by a uranium bomb, and Nagasaki, destroyed by a plutonium bomb, were among other things giant laboratories used to study the effects of these new weapons. The Department of Energy confessed in 1993 that secret human radiation experiments had been conducted between 1945 and 1974 on approximately 16,000 US citizens without their consent. During the 1950s, nearly a quarter of a million GIs were ordered to participate in military maneuvers "under the cloud" during aboveground weapon tests in Nevada to study the psychological effects on troops positioned in proximity to nuclear weapon explosions, the willingness of these servicemen to march to ground zero soon after the detonations, and the ability of soldiers on an atomic battlefield to follow orders and complete a mission. The pristine paradise of the Marshall Islands was used as a testing ground for hydrogen bombs and became a laboratory for studying the environmental effects of these weapons. Ecological studies conducted over a number of years followed the migration of radionuclides throughout the food chains and the progressive internal contamination of natives living on contaminated islands.

Be not in doubt, human radiation experiments are being carried out today. One obvious facet of current US military strategy is the progressive release of greater and greater quantities of radioactivity with each military campaign. From Iraq in 1991 to Afghanistan in 2001 and back to Iraq in 2003, the tonnage of uranium dispersed amidst

enemy populations has steadily increased. Step by tentative step, the US is feeling its way in this new dimension of warfare while simultaneously testing the waters as to what level of radiological warfare the world is willing to tolerate. Heedless of public opinion, the US has weathered backlash from many quarters over its brazen display of it revolutionary radioactive weaponry in the First Iraq War and the criticism lodged against it over its contamination of NATO allies in Kosovo. Emboldened by its success in sidestepping censure, the US has expanded its use of DU weaponry. But to avoid future vilification, it has implemented measures to control the flow of information from the sites of most recent fighting, limiting perception of its deeds, and thus, sanitizing its radioactive befouling of others' homelands. By the Second Iraq War, media access to the war zone was tightly controlled, blinding the world as to what level of radiological warfare was actually being waged.

Warcrafters of the United States are not dummies. The nuclear weapons labs of the nation do not receive billions of dollars annually just to make mistakes. The decision to deploy depleted uranium on the battlefield was made with full cognizance that radiation was being introduced into the arena of battle. However, to escape accountability, spin doctors within the US government have attempted to confound the minds of all humanity with semantic tricks, calling depleted uranium armaments "conventional weapons." Once and for all, it is time to set the record straight. Once fabricated into metal, the uranium atoms within a mass of DU begin undergoing radioactive decay. The uranium and its decay products emit alpha, beta and gamma radiation. When vaporized in an explosion, micron-sized particles of DU are liberated into the environment where they are available for uptake by living systems. *These minute particles of DU are the delivery vehicle for ferrying radiation into the interior of the human body*. As these internalized radioactive atoms decay, their emitted radiation disrupts the molecular integrity of the biological system in which they are embedded. It's a no-brainer. Radioactive atoms cause radiological damage. Depleted uranium is a radiological weapon.

The weaponeers are never idle. A new generation of radiological weapons, designed to penetrate hardened targets, is already coming off the assembly line. These contain advanced guidance systems, a "dense metal" casing or ballast to increase target penetration, and an explosive charge that either detonates on impact or is delayed to detonate in a second stage after penetration. Some of these weapons contain shaped charges that utilize a cone-shaped liner of "dense metal" to focus the direction of the explosive force.

In the mid-1990s, the United States launched a program to enhance the capability of its arsenal. Entitled the Hard or Deeply Buried Target Defeat Capability (HDBTDC), this initiative gave birth to new weapons specifically designed to fulfill two types of military missions: (1) penetrate and destroy underground targets, and (2) neutralize chemical and

biological weapons before their release into the atmosphere. Accomplishing the first task required warheads fabricated from a material of high density. Accomplishing the second required powerful incendiary capabilities. The United States Air Force Mission Plan of 1997 indicated that such weapons would range in size from 250 lbs to 20,000 lbs and would incorporate a "dense metal" to enhance their penetration capability (Williams 2002a, 2002b). At least 23 different weapon systems have been developed that incorporate into their design the mysterious, unidentified dense metal. The largest is the "Big BLU" Bunker Buster bomb which is thought to contain nearly *five tons* of the mystery metal.

Nothing will stop the ongoing proliferation of uranium weapons except the people of the Earth rising up against them in protest. To avoid such unpleasantries, the Cult of Nuclearists is systematically conditioning the public to accept radioactive contaminants on the contemporary battlefield as a fact of life. Seen from this point of view, depleted uranium munitions are a clever ruse; they set the precedent for a future escalation of radiological warfare. With DU ammunition and penetrators now common, the next weapons to be introduced into conflict will be huge bunker buster bombs containing tons of uranium. If a public outcry ensues, authorities will deflect it with the observation that uranium weapons have been in use for years and have a proven track record of being radiologically benign. A further advance into radiological warfare will follow with the gradual introduction into combat of small fission and fusion nuclear weapons. In defense of this escalation, the military will point out that these bombs release no more radioactivity than "conventional" bunker buster bombs. By this means, the vanguard of low-level radiological weapons will seduce mankind into accepting nuclear warfare, and the number and size of detonations will increase. And all the while, hidden by the show, enemy populations, our own soldiers, and perhaps we ourselves will become increasingly debilitated from internal contamination from the dispersed radioactivity.

This plausible scenario highlights why depleted uranium weapons represent a line in the sand in regards to the future of warcraft. If humanity rolls over and accepts DU on the battlefield, the door will never again close on the radioactive onslaught against life.

By what mandate does the US military derive its legitimacy for contaminating humankind's common heritage of clean air, clean water and healthy soil? If collective humanity remains indifferent to unrestrained environmental crimes, it is acceding to its own ruination. For their own protection, all people everywhere, who may someday be caught in the crossfire of a war, need to demand answers to a number of questions: What is the mysterious unnamed dense metal that is appearing with greater frequency in the US arsenal that enable them to penetrate hardened targets? How many weapon systems contain uranium/depleted uranium and in what quantities? How much radioactivity was dumped in

Afghanistan? In Iraq? What are the environmental effects of these weapons? How are they impacting the health of targeted populations and the military personnel of the United States and its allies? Why cloak the answer to the previous question in secrecy and deception? To what extent are uranium/depleted uranium weapons being traded on the world's armament markets? Who now possesses these weapons? In what future conflicts might they appear?

By making depleted uranium available to other nations at little cost, the United States has crafted a situation in which armaments made from this metal are commonplace and embraced internationally as conventional weaponry. This devious strategy has been enacted to help the US escape accountability for the environmental catastrophe it is creating in its current conflicts. To our collective loss, the wholesale proliferation of radioactive metal to armament makers around the world has ensured that future outbreaks of hostility around the globe will involve radiological warfare. Countries known to have DU armaments include the UK, France, Russia, Greece, Turkey, Israel, Saudi Arabia, Bahrain, Egypt, Kuwait, Pakistan, Thailand, Iraq and Taiwan.

The world is flooded with thermonuclear bombs and a plethora of radioactive materials that can easily be weaponized and scattered over the homeland of any people on Earth. This quagmire has engulfed humanity because medical oversight of the armaments of war has never taken precedence over military expediency. The biology of radiation effects is so complex that it is not unreasonable to assume that those responsible for deploying radiological weapons may have no understanding of the force they are unleashing. When Congress appropriates money for the development of weapons containing uranium/depleted uranium, are any legislators cognizant of the extent of radiation injury that will be suffered by our own servicemen and women? When the President orders a preemptive strike with bunker buster bombs against hardened targets of an enemy, is he aware of the extent of radiation injury that he is conjuring for the civilian population in the area? Do operation analysts even consider the medical consequences of the type of weapons they select to accomplish a military objective? Do the generals who wage wars give any thought to the environmental contamination of their weapons to the people who will colonize the once-fierce battlefields after the guns have fallen silent? Who among the warcrafters has the knowledge to wield these weapons responsibly? Can these weapons ever be fielded responsibly? Are these weapons fired despite their radiological effects or because of them? Is the damage to exposed populations just callously written off as collateral damage or is it intentionally induced to debilitate the health and gene pool of the enemy?

There are only two possible explanations as to why uranium weapons are currently in use: either those who wield them don't understand their biological effects or they do. If

the first alternative is true, the politicians and the generals are acting irresponsibly. If the second alternative is true, then they are acting criminally. In either case, it is in the best interest of all life for these men to be separated from their weapons.

A previous chapter of this book examined at length the radiation protection community's corrupted paradigm of radiation effects as it applies to low levels of environmentally dispersed internal emitters. This distortion of science was referred to as the most heinous crime in the history of humanity. Here's why. Those responsible for developing and deploying nuclear and radiological weapons are, for the most part, unschooled in radiation biology. To understand the medical effects of their weapons in combat, they turn to the health physicists schooled in the corrupted paradigm of the ICRP. From these advisors, military generals are supplied with misinformation as to the radiological consequences of the weapons they field. Made ignorant by false information, they order into combat weapons that sicken our own servicemen and erode the health of populations caught in the crossfire of battle. While conscientiously attempting to fulfill their military mission, they unwittingly serve as instruments to contaminate the Earth and introduce debilitating levels of radioactivity into the bodies of unsuspecting humans. The entire ecological balance of the planet and the continued good health of all creatures is being put in jeopardy by corrupted science and the deeds that it spawns.

With military machismo, warriors go off to conquer foreign lands. Configured with more brawn than brain, they fight in ignorance of the fragile unity of nature which they assault. Their gaiety over the loss suffered by others from being targeted by radiological weapons veils them from the realization that divine justice is meted out to tyrants, that victimizers invariably end up victimizing themselves. The Ancients may have learned this truth in scripture. For us today, our oracle is science.

An image search on the internet of dust storms in the Sahara Desert photographed from space by NASA brings to life the ultimate consequences of radiological warfare. Radionuclides let loose in the environment have no respect for national boundaries. Dust from the Middle East is blown to Africa. Dust from Africa is carried to our shores. Deluded by the belief that we are cushioned from the misdeeds of our government by thousands of miles of ocean, we fail to appreciate that the winds, as heralds to our crimes, blow our radioactivity back upon ourselves. When releasing the energy inside the atom to do harm to others, we inescapably do harm to ourselves. This is Ecology 101; nature testifies against human shortsightedness and selfish aggression.

In an interview for the *Iconoclast*, Leuren Moret, a geoscientist who at one time was employed at Lawrence Livermore National Laboratory, offered an insightful description of

the plague being unleashed by releasing DU and other radionuclides over the Earth:

> The atmosphere globally is contaminated with it. It's completely mixed in one year. I'm an expert on atmospheric dust. I'm a geoscientist, a geologist, and that's what I studied and did my research on. It's really a fascinating subject. We have huge dust storms that are a million square miles and transport millions of tons of dust and sand every year around the world.
>
> The main centers of these dust storms are the Gobi Desert in China, which is where the Chinese did atmospheric testing, so that's all contaminated with radiation, and it gets transported right over Japan, and it comes straight across the Pacific and dumps all its sand and dust on the US, North America. It's loaded with radioactive isotopes, soot, pesticides, chemicals, pollution — everything is in it — fungi, bacteria, viruses.
>
> The Sahara Desert is another huge dust center, and it goes up all over Europe and straight across the Atlantic, to the Caribbean, and up the East Coast. Of course, you get it in Texas with those hurricanes. They all originate in the Sahara Desert.
>
> The third region is the Western United States, which is where the Nevada test site is located. We did 1,200 nuclear weapons tests there, so all this radiation that is already there, which is bad enough, has caused a global cancer epidemic since 1945 (Smith and Diebenow).

"Shock and Awe," a phrase coined to seduce the minds of the governed with images of conquest, was the US military's name for its opening aerial campaign against Iraq in 2003. In the first 24 hours, the Coalition of the Willing dropped 1,500 bombs and missiles on Baghdad. (Did any or all of these contain radioactive material? The citizens of the Earth are not privy to such classified information.) To neutralize Iraqi defenses, A-10 Warthogs fired 300,000 antitank rounds which most likely were fabricated with depleted uranium. Despite the desire of the aggressor to bury its radiological crimes behind a veil of secrecy, science, three years later, brought the truth to light.

In the United Kingdom, in January 2006, Dr. Chris Busby and Saoirse Morgan published an article of prophetic importance entitled "Did the Use of Uranium Weapons in Gulf War 2 Result in Contamination of Europe? Evidence from the Measurements of the Atomic Weapons Establishment, Aldermaston, Berkshire, UK." In this work, the authors relate how curiosity into the long-distant transport of radionuclides by meteorological

forces led them to investigate whether elevated levels of uranium had been detected in their country in the aftermath of Shock and Awe. They knew that, since the discovery in the late 1980s of a cluster of childhood leukemia in the area of the Atomic Weapons Establishment (AWE), routine monitoring of the air for the presence of uranium was being performed at a number of locations. Further, they were aware that since 2000, the filters from high volume air samplers were tested every two weeks.

In 2004, Busby applied to the British government facility, which the year before had been taken over by Halliburton, for the air monitoring data which they were required by law to provide. His request was refused. In January 2005, when Britain's Freedom of Information Act became law, an application was made for air sampling data to be released for the period 2000 to 2004. For those readers still in doubt as to the existence of the Cult of Nuclearists and the collusion of well-placed individuals to hide evidence of radiological crimes around the planet, it may come as a surprise that Busby received the data he requested, *except for one period in the early part of 2003, the time of Shock and Awe.* Applying to the Defense Procurement Agency in Bristol for the missing data finally proved successful, and what was discovered in the numbers was truly shocking and awe-ful.

Busby and Morgan discovered that during the two years prior to the military invasion of Iraq, the mean level of uranium in the air at five different monitoring locations was approximately 155 nano-Becquerels per cubic meter. A noticeable elevation in the concentration of airborne uranium first appeared on March 27, nine days after the initiation of the bombing in Iraq. Over the next six weeks, the mean level of uranium in air at the monitoring stations was calculated to be 650 nano-Bequerels per cubic meter, representing an excess of 500 nBq/m^3. On two occasions, the monitoring station in Reading recorded levels of 1000 nanograms per cubic meter which exceeded statutory limits and required reporting to the Environment Agency.

To investigate whether or not the uranium measured in the air could have traveled to the UK. from Iraq in nine days (Shock and Awe had commenced on March 19), Busby and Morgan studied meteorological maps for the period. Their investigation confirmed that air flow patterns were such that dust from Iraq could easily have traversed pathways varying in length from 1,700 to 2,400 miles, the distance from Baghdad to Reading, within the required time. Independent sources confirmed dust from the Sahara arriving in Britain in both February and April.

The researchers also reviewed the literature on the size of DU particles formed from incinerated bullets and penetrators. Previous studies had assumed that a majority of the particles formed were between one and five microns in size. A review of tests conducted by

Particle Diameter Size in Microns	Percent of the Mass of a Destroyed Projectile
< 0.18	31
0.18 - 0.56	14
0.56 - 1.8	15
1.8 - 5.6	13
5.6 - 18	11
18 - 56	7
> 56	9

the US military in the mid-1980s using sophisticated filter systems, however, revealed an entirely different picture (Glissmeyer *et.al*. 1984). Test firings of DU munitions created particles ranging in size from less than 0.18 microns to greater than 56 microns as can be seen in the table (reproduced from Busby and Morgan).

The data of this table is very revealing for it indicates that close to 50% of the dust produced when DU is aerosolized is less than one micron in diameter. This has important physiological consequences in regards to the dispersal of DU in the body. It will also help explain DU's long-distant transport in the atmosphere. As Busby and Morgan observe:

> Thus it is clear that just under half the total mass of the uranium oxide consists of particles smaller than the wavelength of visible light, particles whose behavior may be taken to approximate that of a gas. Therefore the dispersion of such material may be expected to be similar to the dispersion of radioactive gases from nuclear accidents like Chernobyl.

This research offered the first scientific proof that depleted uranium liberated into the environment could travel enormous distances from their point of release. Previous propaganda promoted the view that DU settled to the ground within tens of meters of a destroyed target. Now evidence has emerged that the spread of radionuclides through the environment knows no bounds. When contaminating our enemies, we end up contaminat-

ing ourselves. This is evident in the conclusion reached by Busby and Morgan:

> If this material consisted of uranium oxide particles from the Gulf War bombing then we can first calculate the number of particles of 0.25 micrometer diameter in a cubic meter of air. The activity of uranium is taken to be 12.5 MBq/kg. Thus the mass of 500 nBq is about 4 x 10^{-11}g. Taking the density of uranium oxide as 9.8, there are about 48,000 particles of 0.25 micrometer diameter in one cubic meter. Using inhalation volumes from ICRP standard man (23 m^3 per day; ICRP 1975) and assuming a 50% outdoor inhalation of the uranium per day, in the three weeks of elevated uranium each person would have inhaled about 23 million particles. These particles would have rapidly transferred through the lungs and into the lymphatic system where they would have access to all tissues.
>
> Uranium has a very high affinity for DNA (Nielsen *et al*. 1992, Zobel *et al*. 1961, Huxley and Zubay 1961, Constantinescu 1974) and in cells which have internalized a submicron uranium particle, the instantaneous concentration of uranium will be high enough to have saturated the DNA in the cell by binding to phosphate. This focusing of the radiation on the DNA may be the cause of many anomalous mutagenic effects which show themselves in cell cultures (e.g. Miller *et al*. 2002, 2004) in laboratory animals (e.g. Monleau 2005, IRSN 2005) and in the many reports of ill health associated with exposure to uranium (e.g. Craft *et al*. 2005, Zaire *et al*. 1997) (Busby and Morgan.)

The winds are messengers, carrying dark prophesies of Earth's future: a once vibrant, life-sustaining planet ruined by scheming and ignorant belligerents. No homeland is out of reach from the drift of the radiological offal set loose in modern combat. The Cult of Nuclearists has declared war on the whole of humanity.

Today, there is no military necessity for radiological weapons, and yet they are being fielded. Why?

This question requires deep reflection. It is one of the most important questions of our time, a roadway into the dark machinations of the Cult of Nuclearists. What possible justification can this cabal offer for depositing uranium into the lungs of unsuspecting humanity?

16

Nuclear Colonialism

Bedtime stories are the love of every child. They are a bridge from harsh reality into the comforting world of slumber. Fairy tales enliven the imagination, create an endearing bond between child and storyteller and quell the fears of encroaching darkness.

Adults never quite lose their craving for hypnotic fables. The history books, penned by the victors, are replete with brave accounts of daring, chivalry and laurels. The tale of the development of the atomic bomb is a classic. The standard narrative begins with a portrait of brilliant emigré physicists struggling to understand the ultimate secrets of the atom. As recognition dawns that a chain reaction initiated by fissioning atoms is humanly producible, the purity of their quest becomes tarnished. Then dread overwhelms their hearts as they envision colleagues in Nazi Germany, armed with the same insight, applying nuclear physics to a hellish conquest of the world. Stalwart as righteous knights ready to defend the kingdom, they dispatch a communiqué to Roosevelt, warning of the impending peril and volunteering their services to bring the hellions to their knees. In this story, the United States government is the lumbering hero. It long procrastinates. Then, by fits and starts, it rises to the call. The Manhattan Project is inaugurated, physicists are secretly recruited, clandestine outposts spring up in the wilderness, and a fevered race against time ensues to transform abstract theories into a deliverable weapon. What follows is a blinding accomplishment: Trinity.

As the wafting wind over the New Mexico desert dissipates the radioactive cloud, the setting of this tale switches to the corridors of power. There, a conscientious debate unfolds as to the wisdom of incinerating a metropolis or two of the villainous Japanese. Reluctantly, to save a million brave boys from slaughter in an invasion of the evil enemy's homeland, the

gallant decision is made to drop the bomb. This heroic sacrifice leads rapidly to the cessation of hostilities, victory, and American supremacy in the postwar world.

In the uneasy peace that follows, the "Bomb" becomes the nation's new hero, the guardian of national security and the unrivaled instrument for containing Soviet expansionism. When the Soviets achieve parity with the detonation of their own bomb, an uncompromising duel breaks out between the "superpowers." Mushroom clouds routinely blot out the sun, and terror grips the hearts of all humankind. The puny atom bomb is surpassed by the hydrogen bomb. Ballistic missiles, buried in their darkened silos, point menacingly at the enemy. Submarines creep silently along the ocean depths. Armageddon awaits but an instant away. Then a mighty warrior arises. Single-handedly, Ronald Reagan defeats the evil empire. A new era of peace dawns. Diplomatic negotiations replace nuclear terror as the nuclear haves bond together to prevent proliferation of WMDs into the hands of the nuclear have-nots.

A fine story, indeed.

Such narrative constructions have power. They shape mental landscapes. They create worldviews. They structure behavior. Some stories serve an important political purpose. Those in power tell stories as a means of educating the rest of us to see the world as they wish us to see it. If they are good storytellers, we accept their view of the world and endorse their deeds even though we will not personally profit, and may in fact, ultimately suffer from them.

Our perceptions are shackled by the stories we are told. If we wish to gain a fresh perspective on the entire nuclear enterprise, we must tell stories other than those conjured by the devotees to a culture built on nuclear weapons. One line of storytelling all but absent from our proud history books is the chronicle of those vanquished by nuclear weapon development. The path to the ascendancy of the nuclear powers is paved with exploited peoples, ruined cultures, poisoned lands, disease and death. By compiling this tale, we pay homage to the victimized and in the process, perhaps, catch a glimpse of the breed of man who today rules the world.

Nuclear and radiological weapons did not magically appear one day upon the Earth. They were an artifact, born of the culture in which they arose. The men who fathered them embodied a worldview which had taken shape over centuries. In the process of conceiving and creating these devices of merciless destruction, these men were expressing their values, values forged by their economic outlook, political institutions, military posture, cultural traditions, religious beliefs, attitudes toward foreign cultures, and attitudes about the

environment. Producing the bomb was a bold move, for it was a naked expression of hidden secrets lurking within some human hearts. Ruthless domination, brutality, terrorism, uncompromising threat and the acceptability of mass casualties were some of the values which found expression and embodiment in the Bomb. To endure, the weapons and the mentality which wielded them required the complacency of those who acceded to be governed by this mentality. Such was the inspiration for the vast body of lies and deceptions exposed in this book.

Left to the social psychologists and the historians is the job of explaining the origins of the mindset that felt perfectly justified in developing and deploying weapons of mass destruction. Sufficient for purposes here is the observation that the seeds for this proclivity had already taken root in the minds of the conquerors and conquistadors who set forth from Europe during the period of colonial expansionism. What these men brought to their endeavor serve as a mirror to what men of the twentieth century brought to their project of developing the atomic bomb.

During the Middle Ages, the socio-economic framework of central and western Europe was feudalism and manorialism. The land was the source of livelihood and the economy was fundamentally agrarian. By the thirteenth century, this way of life was in transition. The feudal order began giving way to the rise of national states ruled by royal families. A class of merchants and artisans arose. The population had increased to the point where manorial farming could no longer support it. People began flocking into towns to seek new sources of livelihood. Increasingly, manufacturing and trade supplanted farming as the driving forces of the economy and a money-based system of exchange for goods and services gained acceptance. With a liquid form of wealth in ascendancy, numerous opportunities arose for individuals to make their own niche in the market economy and accumulate personal wealth. The doors were open for upward social mobility on a scale that was unprecedented in feudal society. Accompanying this trend was a new ethic of private property and the absolute right of ownership.

Manufacturing and trade, the buying and selling of goods, created the economic system of mercantilism which arose among the major trading nations of Europe. These nations recognized that their wealth and their power could best be enhanced by exporting more goods than they imported, forcing their foreign trading partners to make up the difference in gold and other precious metals. With bullion universally accepted as a medium of exchange, the wealth of a nation became equated with the size of its bullion reserves. Foreign policy was inextricably bound to foreign trade because this was the means for enrichment of the ruling elite and of the nation. Within this system, overseas traders came to play an essential role in the burgeoning international economy. They transported man-

ufactured goods between trading partners, ferried home the raw materials needed by the manufacturing base of their nation and introduced their people to spices and other exotic commodities from far-off lands.

Within this economy, monarchs and traders sought riches over the horizon. With advancements in cartography, navigation and shipbuilding, expeditions set sail upon uncharted waters to seek out new routes, new trading partners, new commodities and new sources of gold and silver. In their quest to expand their capitalistic enterprises, the seafaring nations of Europe began extending their sovereignty to territories beyond their borders. To administer distant lands and maintain exclusive rights to their resources, settler colonies or administrative dependencies were established and the indigenous populations were either displaced or subjugated.

In the process of colonizing the lands they "discovered" and confronting that which was foreign to themselves, European colonists gave blatant expression to a number of attitudes of mind that had long been nurtured by their culture. Most prominently, colonizers carried within themselves a rigid ethnocentricity. They were convinced of the superiority of European culture, of themselves being the crown of creation, and encounters with aboriginal peoples only served to reenforce this belief. European behaviors, customs, values, patterns of thought, interpretation of events and meaning were good, right and proper, while those of foreigners were inferior and primitive. Coupled with this attitude, or perhaps because of it, colonists believed themselves entitled to lay claim to the lands of others in the name of king or queen and country. Although the right to private property was recognized in Europe, property rights did not extend to native populations. Needless to say, the superiority of European culture and the right to the expropriation of native lands and resources was given teeth by steel sword, armor, gunpowder and cannon.

As adherents to Christianity, colonizers held the unwavering belief that they were in possession of the only true religion. This attitude of spiritual and moral superiority alienated them further from the indigenous peoples they encountered and blinded them to the experience of the sacred which was woven into the lifestyles and observances of those they judged to be heathens. An important aspect of this spiritual divide related to differing attitudes toward the land and nature. By the time of colonial expansion, Europeans generally were alienated from the land and scared of nature. The natural world was primarily a backdrop to life. Its chief value lay in its utility. Land was lifeless, without spirit, and the plants and animals were present in the world to be of service to mankind. Over the centuries, this attitude gave license to numerous environmental abuses in conquered territories which included strip mining, clear-cutting forests, intensive mono-cropping, overhunting, overfishing, and various types of pollution. The utilitarian value of nature, however, was

compromised by its unpredictability. Seen as capricious, nature was perceived as a frightening adversary that required taming. No wonder that the scientific revolution of the seventeenth century, focusing on the conquest, domination and control of nature, was of European origin (Pattberg). In stark contrast, aboriginal people living off the land were so alien to Europeans as to be incomprehensible. Their way of life was integrated with the natural world. Their survival and livelihood depended on their knowledge of nature and their ability to harmonize with the forces at play around them. The direct experience of the interrelatedness of all aspects of the natural world provided for them a never-ending source of spiritual inspiration. The land was sacred and valued for itself. It was the key to divine mysteries, and it inspired reverence.

The subjugation of native peoples was followed by economic exploitation. Reaping the rewards from colonized lands required cheap and abundant labor. The most readily available work force was the native population. Pushed off their land and robbed of their traditional lifestyles, members of native populations were forced into servitude or willingly submitted to exchanging their labor for the bare necessities of subsistence. After the discovery of the New World and the bounties which it promised, the colonizing powers were forced to experiment with different labor practices. Some colonies modeled their economy on feudalism, transforming native inhabitants into serfs. In other colonies, labor was provided by indentured servants brought over from Europe. A successful resolution of the labor problem in the Americas and the Caribbean colonies was finally resolved by the mass importation of slaves from Africa.

In the process of intermixing with native cultures, European colonizers succeeded in imposing their sociocultural traditions and values on their wards. The introduction of European languages was an invasion of the mental landscape of the conquered, creating new cognitive structures and meanings. Over time, native culture and native wisdom were lost. Generations of people cut off from their roots, displaced and alienated from the culture that overwhelmed them, sank into poverty, substance abuse, mental illness and suicide. Alternatively, native peoples, clinging to remnants of the traditional life of their ancestors, took up residence on marginal lands which remained pristine only because they lacked economic value.

There is no other term but racism that adequately describes the European attitude toward colonized populations. The ethnocentricity, moral superiority, cultural arrogance, feeling of entitlement to others' land and wealth, the exploitation, the imposed servitude could not have been rationalized over and over again without the underlying conviction of white Europeans that they and their culture were superior and deserved to dominate what they perceived as inferior races. More the rule than the exception, when white Europeans

encountered peoples of color, what followed was bigotry, prejudice, oppression and violence. The holocaust suffered by native populations throughout the Americas provides clear testimony of the uncompromising ruthlessness of the European invaders.

Oh, if only we could comfort ourselves by relegating the crimes of colonial expansionism to a bygone era, distancing ourselves and our supposed enlightenment from the deeds of our backward ancestors. But to do so would be reprehensible. In truth, the same ugly vector of attitude and behavior that facilitated colonialism has been an indispensable element in the development of nuclear weapons and the current deployment of radiological weapons. This fact is conveniently overlooked by the storytellers of our age. Their histories are mute as to the fact that nuclear weapons and reactors would not exist without human rights abuse, ill treatment of indigenous peoples, the expropriation of resources from traditional landholders, environmental devastation and indifference to the safety and well-being of just about everybody. To aptly characterize this phenomenon, activists have coined the term "nuclear colonialism." This expression denotes the appropriation of aboriginal lands and the exploitation and oppression of aboriginal peoples for the purpose of developing, testing and deploying nuclear and radiological weapons. Subsumed within this term is an interrelated concept: "environmental racism." Wikipedia provides a quite adequate definition of this phenomenon: "Environmental racism is intentional or unintentional racial discrimination in the enforcement of environmental rules and regulations, the intentional or unintentional targeting of minority communities for the siting of polluting industries such as toxic waste disposal, or the exclusion of people of color from public and private boards, commissions, and regulatory bodies." The bond between nuclear colonialism and environmental racism is made bitingly clear in this observation by Anne Herbert and Margaret M. Pavel:

> Racism makes the continuing production of nuclear waste possible. If the white people who make decisions about nuclear waste felt that the people of color in poor areas are as valuable as the decision makers' own mothers and fathers and sons and daughters, would they continue to dump nuclear waste in those areas? If tailings from uranium mining were located next to the homes of investment bankers instead of the homes of indigenous people, would uranium mining continue? The continuation of the nuclear fuel cycle depends, in effect, on the practice of human sacrifice. It depends on affluent whites deciding to risk the health and lives of people who are not affluent or white. This is what 'acceptable risk' often means in practice (Herbert and Pavel).

This portrait of those who today actively practice human sacrifice is not without

validity. People who control nuclear and radiological weapons are not stupid. Fully cognizant of the lethality of radiation exposure, they strive their utmost to put as much distance between themselves and the radioactive offal they unleash. They flex their subatomic might far from their centers of power and, both by accident and design, decimate Third World peoples, ancient cultures and devotees of non-Christian religions. To date, the testing of nuclear weapons and the deployment of uranium weapons by the nuclear powers evidence an ugly campaign of ethnic and religious discrimination and subjugation. Ancestral homelands and food supplies are contaminated. Sacred grounds and holy shrines are desecrated. Populations are uprooted at best or at worst left to suffer epidemics of radiation-induced illnesses. Such open disdain for so-called "marginal" people by the lordly possessors of infernal weapons is an indelible sign of their cold cruelty, cultural arrogance, and will to supremacy. We who have yet to taste the bitterness of nuclear devastation and radiological ruination, what guarantees do we have that we will not be the next victims? With the coming of the first nuclear exchange between nations, all of us will be rendered marginal people, victimized, dehumanized and incinerated by the machinations of the Cult of Nuclearists. Lest we lose sight of the crimes foreshadowing Armageddon, it behooves us to remember the ethnic cleansing made possible by the splitting of the atom.

Nuclear weapons are built upon nuclear colonialism and environmental racism. This is a sad commentary on the type of people who embrace these weapons and the mentality they harbor. In the process of developing nuclear weapons, bomb builders must fulfill certain basic requirements. Three of these will be considered here because, historically, they provoked a confrontation with indigenous populations and were resolved by actions arising from a colonial and racist mentality. First, the development of nuclear weapons is contingent upon a large supply of uranium. By some quirk of fate, the major uranium deposits of the world are located beneath marginal lands occupied by aboriginal peoples. As a consequence, native landholders have borne the brunt of uranium mining operations. They have been forcibly removed from ancestral lands, suffered the destruction of sacred sites, been exploited economically, witnessed environmental devastation and made ill from radiogenic diseases. Second, a weapon once built requires a test ground. Bomb builders are not stupid. Aware of the hazards of fallout, the contamination of local food chains and water sources, the risk of radiation-induced cancers and birth defects, they select test sites far from their own homes where families and friends will remain unharmed. That the lands of marginal people will be hopelessly contaminated, that these people and their progeny will be the victims of radiation exposure, was never a deterrent to weapon testing. Third, nuclear weaponeers require a repository to store waste generated by their enterprise. Since radwaste will remain hazardous for hundreds of thousands of years and no one is able to predict the long-term security of any storage method, the preferred solution of the nuclear waste stockpilers is to bury their waste far from the centers of their own power.

Today, multinational mining and energy companies provide uranium to a world market. At the beginning of nuclear age, however, the situation was different. Uranium was in short supply and plentiful deposits had yet to be discovered. Those nations aspiring to go nuclear were forced to seek out their own uranium reserves, and the places where they prospected and mined were, more often than not, located in former colonies that had previously been subjugated and exploited. Uranium for Soviet weapons was mined in East Germany, Czechoslovakia, Estonia, Ukraine, Kazakhstan, Kirghizstan, Tadjikistan and Uzbekistan. A windfall of major uranium reserves fell into the lap of the Chinese through their conquest of Tibet. Morocco, Niger and Gabon were sources of uranium first acquired by France. Great Britain's supply came from Australia, Canada and Namibia (via South Africa).

Uranium mining and milling are particularly dirty industries, devastating the local environment. With uranium constituting only a small percentage of mined ore, mountains of radioactive waste spring up on the landscape around uranium mills. Uranium and the radionuclides from uranium decay are abundant in mill tailings and invariably end up contaminating groundwater, rivers, lakes and aquifers. Mill wastes also emit radon gas. While airborne, radionuclides from radon decay, principally lead-210 and polonium-210, settle out of the air, contaminating local flora and fauna. A study in northern Saskatchewan of radionuclides released into the environment from uranium mining confirmed the efficiency of lichens in accumulating airborne radionuclides (Thomas and Gates). Contaminated lichens then become a food source to grazing caribou which accumulate radionuclides in their tissue. In turn, native peoples of the area hunt the caribou for their subsistence, thus inadvertently overloading their bodies with internal emitters.

In addition to contaminating the countryside with radioactivity, uranium mining releases other pollutants into the environment that gravely impact the local ecology. Heavy metals increase water acidity. Chemicals from milling processes, notably ammonium and nitrates, are also released in abundance into the surrounding environment. The uranium mine at Elliot Lake in Ontario has been studied extensively and can be used as a model to demonstrate the impact of uranium production on the environment. In 1971, the Ontario Water Resources Commission reported that lakes in the vicinity of the mine were contaminated with radium-226, emitting radioactivity at 50 times background levels. This represented 15 times the maximum water quality level set by the government of three picocuries per liter (Moody). Even after remedial efforts which included dilution, reduction in mining and new treatment facilities were introduced in 1978, local drinking water levels of radium remained two to four times greater than permitted by government limits (Moody). In The *Gulliver File: Mines, People and Land — A Global Battleground*, Moody describes how government stepped in to aid the mine in dealing with its radium pollution problem:

> Alarmingly, barely two years later, a federal provincial committee recommended that, instead of lowering radium levels to meet health criteria, the standards themselves be lowered: this was in line with a recommendation by the ICRP that maximum permissible radiation for bone marrow could now be increased nine times. Sister Rosalie Bertell, of the Jesuit Center in Toronto, and a world expert on radiation (with special knowledge of Elliot Lake) called the decision 'murder.' In her opinion, 'the blatant reason for the change is because the radium is too expensive to clean up.'

A waste product of the milling process is sulphuric acid, which routinely contaminates water sources. In this high acidity, radium, thorium and uranium dissolve more readily, increasing the mobilization of these radionuclides from mill wastes into the environment. In addition, the increased acidity of water in the vicinity of Elliot Lake was responsible for the death of aquatic life. Mature freshwater fish are unable to survive when acidity/alkalinity is outside the range of pH 5 to pH 9 (Moody). In 1980, the acidity of May Lake was similar to that of vinegar, pH 3.1. According to Moody, the increasing acidity in water has other repercussions:

> Acidity levels are inversely linked to the dangers posed by heavy metals: the higher the pH, the more gas given off by ammonium liquid. At Quirke Lake, concentrations of ammonium have exceeded the Ontario Drinking Water Quality Criteria, while high concentrations of nitrogen compounds have been located some 40 km downstream of the mine. Iron levels at May Lake, copper levels at Quirke and Dunlop Lakes, have given cause for concern in recent years. Copper is especially threatening to fish. (It kills young salmon at 0.1 ppm [parts per million] — one tenth of the human drinking water limit — and can prove poisonous to sheep at 0.5 ppm). Copper levels measured downstream of the Quirke Lake facilities have reached 0.11 ppm, and at Dunlop Lake, 0.58 ppm.

Although the subject matter is vast, a few broad strokes can paint a picture of the impact that nuclear colonialism and environmental racism have had on communities of indigenous peoples living atop uranium deposits. Prior to the uranium booms of the 1950s and 1970s, two thirds of the uranium deposits in the United States were located in the Four Corners region of the southwest, at the meeting of the borders of New Mexico, Arizona, Utah and Colorado. This undeveloped desert landscape was the home to bands of Native Americans and deposits of uranium were discovered mostly within the boundaries of their reservations. Aided by the Bureau of Indian Affairs, mining companies leased millions of acres of tribal land for uranium exploration, the digging of mines and the

construction/development of uranium mills. The native population profited little from this activity, receiving on average 3.4 percent of the market value of the uranium extracted from their lands (Kuletz). Peoples of the Navajo Nation, Laguna Pueblo and Acoma Pueblo suffered the greatest impact from this invasion by the large energy companies. Their familiar pastoral economy was rapidly transformed into a mining-industrial economy, and they became a mining-dependent population (Kuletz). Recruited as a cheap source of labor for the mines, Native Americans were exploited economically, receiving two-thirds the salary of employees brought in from off the reservation (Churchill). During the uranium boom of the 1970s, the median salary for the Laguna Pueblo was 50 dollars per week (Kuletz). Maximum economic gain for the mining companies was the driving force for the abuses showered on Native American communities in the Four Corners region:

> Rather than cultivate invisibility for reasons of secrecy, the uranium industry exploited the low visibility and lack of political power of the semisovereign Indian nations (reservations) to bypass environmental protection standards and job safety regulations, to bypass (for decades, and with the cooperation of federal agencies) their responsibility to inform uranium miners of the deadly hazards of their occupations, as well as to ensure a high profit margin in the extraction, processing and sale of uranium ore to the secret scientific-military complex (Kuletz).

During the initial uranium boom of the 1950s, working conditions in the 2,500 mines then in operation were abysmal. The Atomic Energy Commission ceded oversight of mine safety to state agencies whose employees did not possess adequate knowledge of radiation effects and who remained uninformed of the European experience that uranium mining induced lung cancer. What resulted was a public health tragedy, largely borne by the Native American miners, that could have been avoided if mining companies had been required to invest in adequate ventilation equipment. After years of data collection and epidemiological studies, it became obvious to state officials that an epidemic of lung cancers was in progress, but by that time the damage to the health of miners had been done. Numerous anecdotal reports gathered from Native American miners agree that mine operators never informed them of the possible hazards of uranium mining, that no one cautioned them against drinking from the water trickling through the mines, that no one ever discouraged them from eating their lunch with dust-covered hands.

Besides the miners, Native American communities located in proximity to uranium mining operations also suffered increased incidence of disease. According to a 1981 study by the Navajo Nation's Division of Health Improvement Services, teenagers living near mining operations in Shiprock, Farmington and Grants, New Mexico, suffered rates of organ cancers 15 times higher than the national average (Taliman). Other studies are

described by Kuletz:

> In seeking federal assistance to study the effect of low-level radiation on the health of their children, Navajo health officials called attention to at least two preliminary studies — one conducted by the March of Dimes (principal investigator Dr. L. Shields) and the other by the Navajo Health Authority (principal investigator Dr. D. Calloway). Calloway's study suggested that Navajo children may have a five times greater rate of bone cancer and a 15 times greater rate of ovarian and testicular cancer than the US average. However, despite these preliminary findings, no funding was granted for extended epidemiological studies of the impact on Navajos living near uranium tailings and mines.
>
> Many 'preliminary studies' suggested serious health risks to children in communities near abandoned uranium districts. One 'preliminary' study showed 'a twofold excess of miscarriages, infant deaths, congenital or genetic abnormalities, and learning disabilities among uranium-area families' compared with Navajo families in non-uranium areas. Even after being informed of these and other findings, no federal or state agencies provided funding for further study. In fact, in 1983, one agency, the Indian Health Service (a division of the US Department of Health and Social Services) had sent a report to Congress ("Health Hazards Related to Nuclear Resources Development on Indian Land," 1983) stating that there was 'no evidence of adverse health effects in Indians in uranium development areas and that there is no need for additional studies or funding for such studies.'

In addition to adverse health effects, uranium mining brought environmental ruin to tribal lands. Gaping scars blemish the landscape from the 1,000 or more abandoned and unreclaimed open-pit and underground mines (Kuletz). Millions of gallons of water used for uranium extraction became hopelessly contaminated with radioactivity. As a byproduct of the separation and concentration of uranium from ore, uranium mills created huge mountains of radioactive mill tailings. Remaining uncovered, mill tailings remain a perpetual source for pollution of the environment. Wind scatters the dust from these mountains over the landscape, continually contaminating water, soil and crops and creating a perpetual inhalation hazard to residents of the region.

The most severe radiation accident in US history occurred at Church Rock, New Mexico, on July 16, 1979. A dam at a uranium mill owned by United Nuclear Corporation

broke and released into the Rio Puerco 1,100 tons of mill wastes and 100 million gallons of radioactive water. This waste contaminated the river for at least 60 miles downstream. The Navajo people living along this watercourse were never adequately informed that their single source of water had been rendered a health hazard. Unaware of the danger, families continued to draw drinking water from the river. They continued to give their livestock unrestricted access. Children continued to swim in the waters. Kuletz provides additional information:

> The Rio Puerco was not a clean river prior to this accident. As noted by one groundwater protection researcher: "Between 1969 and February of 1986, the Puerco flowed year-round, fed by millions of gallons of contaminant-laden water that poured daily into one of its tributaries (called the North Fork) from three underground uranium mines. No one bothered to tell the Navajos that the water that poured from the mines during the uranium boom years of 1952-1964 and 1969-1981 was not safe for man or beast."

The Church Rock disaster was not an isolated incident. Between 1955 and 1977, 15 dams holding back mill tailing wastes broke. In a region of scarce water resources, these accidents had a disastrous ecological impact.

For the purposes of creating weapons of mass destruction, nuclear colonialism exploits marginal people living away from the centers of power. Invariably, this process has led to a ruination of the environment in which these people dwelt. Hidden within the heart of this ugly phenomenon is racism practiced by the white, elite members of society against disadvantaged Native Americans. Again, Kuletz pulls back the veil:

> Today — seemingly as invisible as the Rio Puerco accident — the uranium mines and tailings are, for the most part, left unreclaimed. Although a 1983 Environmental Protection Study confirmed that the Navajo Reservation alone had approximately 1,000 significant nuclear waste sites, the Environmental Protection Agency (EPA) deemed them all 'too remote' to be of 'significant national concern.' A 1978 study by Los Alamos National Laboratory (LANL) concerning rehabilitation of land and water contaminated by uranium mining and milling offered one solution: to zone such areas as forbidden to human habitation. A report in 1972 by the National Academy of Science suggested that the Four Corners area be designated a 'national sacrifice area.' Other scientific accounts were completely contrary to these findings and denied that any significant pollution problems existed or that adverse health effects could be associated with living in

> the region. Though seemingly different in content, all these reports belie the same prejudice: The land, and by implication the people living on the land, were better left ignored. That is, neither was worth saving.

The desecration of sacred lands by uranium mining interests is neverending. A particularly appalling example became public knowledge in 2008 when newspapers reported that VANE Minerals, a UK mining company, was petitioning the US government for mining rights in the Grand Canyon. Granted exploration permits by the US Forest Service, the company planned to drill at 39 spots located on seven sites within the Kaibab National Forest between the north and south rims of the canyon (Ayres). Due to expectations that high grade uranium ore is located in the area, other mining companies are scrambling for a piece of the action with as many as a thousand claims pending. In an attempt to head off an ecological catastrophe, environmentalists and Native American tribal leaders challenged the permits granted to VANE Minerals in the US District Court. The federal judge issued a temporary restraining order. A full hearing was expected sometime during the second half of 2008. Opponents to uranium mining in the area cited numerous objections. Besides irreparably marring one of the natural wonders of the world, the threat to local widelife was a primary concern. In addition, the Colorado River is the source for agricultural irrigation for much of the southwest and a major source of drinking water for the city of Los Angeles and other metropolitan areas in southern California. Contamination of the river would produce incalcuable harm.

Nuclear colonialism and environmental racism are not unique to the United States. They are embedded in the mentality that assesses nuclear weapons as appropriate technology and a reasonable instrument of national defense. All of the major nuclear powers share a history of ruining the homeland of indigenous populations and exploiting the inhabitants while questing for the means of nuclear mass destruction. What they have done while in pursuit of the technology is what they plan to do to their enemies at a moment of national crisis.

The homelands of indigenous peoples in Australia, Africa, Asia and North and South America sit atop 70 percent of the world's uranium reserves. The hunger of large mining and energy companies to capitalize on this resource repeatedly has taken precedence over the interests of traditional landholders. In experiences mirroring those suffered by Native Americans, mining companies bequeathed to aboriginal societies unreclaimed mines, mountains of uranium mill tailings, contaminated waterways and an increased incidence of disease. In the process, native cultures were systematically dismantled as people were herded off their lands, dispossessed of their sacred sites and forced to abandon their traditional lifestyles.

What occurred in Australia is a mirror image of the holocaust visited on Native Americans. When the British claimed sovereignty over Australia, they commenced a 200-year campaign of dispossession, oppression, subjugation and genocide of Aboriginal peoples. Describing Australia's treatment of indigenous people, two judges of the High Court of Australia once summed the experience as "a national legacy of unutterable shame" (Muurlink and Sweeney). The colonial mentality that justified the colossal abuse throughout settlement of Australia was carried into the nuclear age when native rights came into conflict with the British need for uranium and a remote region to conduct weapon testing. Thirty-three percent of the world's economically recoverable uranium reserves are located in some 50 deposits throughout Australia. Mining companies in Australia, with tacit approval of the federal government, have aggressively pushed aboriginal peoples off their lands. In the wake of their operations, they ruined the environment at El Sharana, Moline and Rum Jungle. Repeatedly, the rights and interests of such groups as the Kokatha, Martu, Adnyamathanha and Mirarr peoples have been ignored. To quote the Western Desert people:

> The mining companies continue to move over our land destroying our sacred sites and vegetation as well as disrupting animal life without consultation with the very people that this affects the most. We have lived in this land for thousands of years, yet legally we are not permitted to build permanent structures for housing and by law can be removed from the land we occupy (Muurlink and Sweeney.)

Mining companies and government officials have repeatedly coerced the Adnyamathanha people to accept mining operations on their lands. Richard Salvador of the Pacific Islands Association of Non-Governmental Organizations has painted a stunning portrait of the types of abuse showered upon these native Australians by those seeking mining concessions:

> Over recent years the process of these mines becoming operational has seen repeated attacks on the Adnyamathanha people. Women and men are being physically assaulted in Native Title meetings, in the presence of lawyers employed under Commonwealth funding grants to administer Native Title. Children as young as 9 years old are being sprayed in the eyes with capsicum spray by police at a site of protest, whilst adults are being confined in police vehicles for up to 7 hours in 40 degree Celsius heat, without water. Public meetings are being held by mining companies accompanied by armed police and chaired by the current local member of Parliament. At the request of members of Parliament, Adnyamathanha people are 'escorted' from the meet-

> ing by armed police for demanding an independent Chair. These experiences are far from peaceful, and do not empower Adnyamathanha in relation to managing their heritage in a culturally appropriate manner. Bullying, bribery, emotional and physical abuse, racism and prejudice are the terms of reference used by the Australian government, the mining industry, and the legal system. Those Adnyamathanha who openly challenge the legal system and the government policies as an inadequate and inappropriate framework for consultation are punished, marginalized and reputed as "radical" and "unreasonable" (Salvador, 2002).

The Ranger mine is located in the Northern Territory of Australia within the world heritage-listed Kakadu National Park. Since 1981, there have been 120 releases and leaks of contaminated water into the local watershed. Not surprisingly, the health of Aboriginal people living in proximity of the mine was never assessed. Then in 2006, a paper was published by the Australian Institute of Aboriginal and Torres Strait Islander Studies which reported that the incidence of cancer was nearly double the expected rate among people living in proximity to the mine. In this study, the number of Aboriginal people living in the Kakadu region diagnosed with cancer were compared to the number of cancers of all Aboriginal people in the Northern Territory from 1994 to 2003. Among those dwelling near the Ranger mine, 27 cases of cancer were reported which represented a rate 90 percent higher than expected (Minchin and Murdoch).

Twenty percent of the world's uranium is mined in Canada. Some of the uranium for the Manhattan Project was mined at the government-owned Eldorado Mining and Refining Company at Port Radium in the Northwest Territories. For three dollars a day, men of the Dene community were employed to haul 45 kilogram sacks of uranium ore out of the wilderness to Fort McMurray. Typically, they carried their burdens 12 hours a day, six days a week, four months a year (Nikiforuk). "Highway of the Atom" is the name now given to the 2,100 km trek across the tundra, barge trips down rivers and portages around rapids. The Dene dwelling near the mine ate fish caught in contaminated dredging ponds. Their children played in the dust and ore at river docks and portage landings. Women sewed tents from the sacks used to haul the ore (Nikiforuk). While sailing downstream, boatmen slept atop the ore. A 1994 federal study on radioactive waste identified an area of "elevated gamma radiation, due to spillage of uranium ore" which had been routinely used by a dozen families for hunting, fishing and camping (Nikiforuk). The Dene paid a heavy price for their service. An aboriginal health survey conducted in 1991 by the government of Canada found that the community reported twice as much illness as any other Canadian aboriginal community. Elevated rates of cancer are reported among the male uranium workers.

As outlined by Andrew Nikiforuk, an apparent crime lay at the heart of this tragedy. Declassified documents from the atomic weapons and energy program in the United States confirm that official secret talks on the health hazards of uranium mining were discussed both in Washington and Ottawa. In 1932, even before the Manhattan Project, the Department of Mines in Canada published studies of the mine at Port Radium, warning of the hazard of radon inhalation and "the dangers from inhalation of radioactive dust." Blood studies of miners confirmed that breathing air with even small amounts of radon was detrimental to health. Most disturbingly, the ill health which was to befall aboriginal miners in the US and Canada was predicted in 1942 by Wilhelm C. Hueper, the founding director of the environmental cancer section of the US National Cancer Institute. After reviewing 300 years of data collected from uranium and cobalt mining operations in Europe, he concluded that "radon gas in cobalt mines routinely produced lung cancers that systematically killed more than half of all miners 10 to 20 years after their employment" (Nikiforuk). Referring to radium miners at Great Bear Lake in the Northwest Territories and in the Belgian Congo, Hueper made this dire prediction:

> In case the Belgian and Canadian operations should be conducted without the essential and comprehensive protective measures for the workers, the prospects for an epidemic-like appearance of lung carcinomas among their employees can be anticipated in the not-too-distant future.

According to documents declassified in the US, the Atomic Energy Commission intervened in Hueper's work, informing him that talk of the occupational hazards of uranium mining was "not in the public interest" and "represented mere conjecture." Nikiforuk continues, relating an incident that occurred in the mid-1950s after cancers began being diagnosed at Port Radium. A government study was conducted which found elevated levels of radon in the mine and in a second mine at Lake Athabasca. When printed and ready for release, the authors were ordered by Canadian government officials not to circulate their document. The follow-up? In 1959, the Canadian Minister of Energy, Gordon Churchill, made the sickening public statement "that there are no special hazards attached to the mining of uranium that differ from other mining activities." In a written history of the Canadian government's Eldorado mining company by Robert Bothwell of the University of Toronto, this revealing statement can be found: "The profound and deliberate falsification of nuclear hazards began at the top."

In northern Saskatchewan near Lake Athabasca, rich deposits of uranium have been mined since the 1940s on land inhabited by the Dene and Cree peoples. The native populations rely on the land for subsistence hunting. At the Indigenous World Uranium Summit in 2006, Jamie Kneen of Minewatch Canada reported how uranium companies

during the 40s and 50s routinely dumped uranium mill tailings directly into lakes and rivers. When dams were later installed to hold back the tailings, contaminated runoff continued to pollute the environment (Norrell). Investigations have confirmed radionuclide contamination of the food chain in the area of uranium mining operations and a transfer of this contamination to native populations as a result of the consumption of wild caribou (Thomas and Gates).

In the area of Elliot Lake in northern Ontario, the Anishinaabe people have been adversely affected. The Serpent River watershed, including 80 kilometers of the river and 10 lakes, is highly contaminated as the result of mine operations. In addition to uranium mining operations, this environmental degradation was created by the rupturing of 30 dams holding back uranium mill tailings and contaminated water. Further environmental catastrophes at Elliot Lake are related by Moody:

> This environmental "bill of account" would not be complete without some discussion of "accidents" resulting from mine operations at Elliot Lake. These include unexpected seepages, unintended movement of solid wastes, dam and dike failures, re-solution, or erosion, of barium-radium precipitates, waste pipeline breaks, pump failures, a decant tower collapse, the accidental release of a large volume of sulphuric acid and release of fine sands in the decant effluents. In 1964, some 82,000 tonnes of waste drained into Quirke Lake, due to "overtopping" of the dam. And, in 1979, within a month of the Panel mine and mill being modernized, a tailings line broke, leading to liquid and solid contamination of Quirke.

In underground mines in Canada, no regulatory upper limit to radiation exposure was initiated until 1968 (Brooks and Seth). A study of 50,201 Canadian miners working between 1955 and 1986 disclosed an excess of 120 lung cancer deaths over the 171.8 expected in the nonexposed population (Brooks and Seth).

China's annexation of Tibet has given it access to major uranium deposits. Rich deposits are mined in Damshung, north of Lhasa, Qaidam, north of Golmud, Yamdrok Tso, and Tewe (Dekhang). At Tewe, inhabitants report increased incidence of illness and deaths caused by polluted streams below the mine (WISE 1993). Tibetan refugees escaping to India have confirmed these reports, adding stories of mysterious die-offs of domestic animals and the unexplained withering of trees and grasses (Dekhang). Sun Xiaodi, a whistleblower from northern China, was under house arrest at the time of the Indigenous World Uranium Summit in 2006. But his message was smuggled out of China and delivered to the attendees by Feng Congde of Human Rights China (Norrell). Xiaodi reported

massive uranium contamination from Chinese mines operated in Tibet. At one time, Xiaodi worked in Uranium Mine number 792. Originally run by the Chinese military from 1967 to 2002, it was transferred into the hands of Longjiang Nuclear Ltd., whose shareholders were politicians and members of the nuclear ministry. Xiaodi's written statement described how the mines routinely released under cover of night untreated, irradiated water into the Bailong River, a tributary of the Yangtze. Said Xiaodi:

> Today, large sweeps of Ansu Province — dotted with sacred sites — appear to have succumbed to an overdose of chemotherapy. The Chinese have taken no preventive measures to protect local human and animal life from uranium contamination.
>
> At present, in our region there are an unusually high number of miscarriages and birth defects, with many children born blind or malformed.

According to Xiaodi, Tibetan workers have reported that nearly half the deaths in the region are produced by cancer and immune system disorders. Patients' medical histories are routinely falsified by authorities to protect state secrecy.

The uranium first used in French nuclear weapons was acquired from the Shinkolobwe deposit in the Belgian Congo. As of 1980, 70 percent of France's uranium came from Niger and Gabon in West Africa (Kuletz). Other European countries and Japan also acquire uranium from these nations for their commercial nuclear power industry. The mines are run by the French company Cogéma (parent company Areva), but they are not operated under the same health and environmental regulations enforced within France (Brooks and Seth). In 2005, Somair and Cominak, the subsidiaries of Cogéma that run the Niger mines received a rather poor corporate responsibility rating of Level 2 in the environmental area (on a 4-level scale with 4 being the best rating) from the rating agency Vigeo. Level 2 stands for Prudent: "The company is dealing with the risks at a minimal level." The issues of waste management and rehabilitation of the environment were important contributors to the earning of this rating. In 2003, representatives of the independent French monitoring laboratory CHIIRAD made a field trip to Niger to observe the conditions of the uranium mines at Arlit and Akouta. Members noted the nearly total absence of any form of waste management. Deposits of waste rock and uranium mill tailings remained exposed, representing a source of radioactive dust that might migrate through the environment. Further, they noted the lack of effective restrictions on local residents scavenging contaminated metal scrap. This became an issue in 2006. The BBC (BBC News, May 30) reported people living near Arlit were ill as a result of exposure to radioactive scrap metal. In 2007, in the town of Akokan near the Akouta uranium mine,

radioactive waste rock was being reused for local road construction.

Great Britain's nuclear weapons program was partly fueled by uranium mined in Namibia. In the 1970s, Namibia was illegally occupied by South African armed forces. In 1976, the British-Australian mining company Rio Tinto Zinc (RTZ) began illegally mining uranium at Rössing in violation of a 1974 UN decree that no Namibian natural resources could be extracted without the consent of the UN Council for Namibia. The decree specifically included these words:

> No person or entity, whether a body corporate or unincorporated, may search for, prospect for, explore for, take, extract, mine, process, refine, use, sell, export of distribute any natural resource, whether animal or mineral, situated or found to be situated within the territorial limits of Namibia (Edwards 1983).

This decree was totally ineffectual in stopping RTZ's mining operations. The veil, behind which the company attempted to hide its operations, was pulled aside in *The Plunder of Namibian Uranium*, a United Nations booklet published in 1982:

> Mined by virtual slave labor under brutal and unsafe working conditions, transported in secrecy to foreign countries, processed in unpublicized locations, marked with false labels and shipping orders, owned by a tangle of multinational corporations whose activities are only partially disclosed, and used in part to build the nuclear power of an outlaw nation (Edwards 1983).

RTZ's Rössing mine was notorious for human rights abuses:

> Rössing has become synonymous with neocolonialism, the perpetuation of apartheid, flagrant disregard of international law, and the symbiotic relationship between civil and military nuclear fuel supplies. To the United Nations Council on Namibia (UNCN), the mine has epitomized the illegal seizure of vital resources from a territory until recently cheated of its independence. To Namibia's government, led by SWAPO (South West Africa Peoples' Organization), Rössing was the single greatest bulwark of apartheid in the country for over a decade. To its workforce it is a danger for years to come (Moody).

In the article "Rio Tinto: Founded on Blood," Sue Boland had this to say:

> In every continent where Rio Tinto operates, the story is the same:

> land taken from indigenous people without compensation; workers prevented from freely organizing in trade unions; destruction of the environment; and cozy relations with politicians, government officials and dictators.
>
> At its Rössing mine, Rio Tinto maintains racial segregation in company housing. Black employees are paid rock-bottom wages while their white counterparts are paid above the maximum of the common scale, in what is called an inducement band.
>
> In dealing with indigenous peoples' opposition, Rio Tinto usually begins negotiations with several indigenous groups. Once it establishes which group can be bought off, it ceases negotiations with all the others and claims that it has indigenous support for its project.

As a player in the uranium supply chain, Canada ignored both the UN decree and the flagrant human rights violations and refined the uranium mined in Namibian at Port Hope. This little-known fact came to light in the article "Canada's Nuclear Industry and the Myth of the Peaceful Atom:"

> The practice of refining Namibian uranium at Eldorado's federally owned facility in Port Hope, Ontario, was already well established by 1974, and continued uninterrupted into the 1980s. RTZ's Canadian subsidiary, Rio Algom, actually owned 10 per cent of the Rössing mine, and Falconbridge Nickel — a Canadian subsidiary of Superior Oil of Texas — had been exploring for uranium in Namibia since the mid-1970s. The Canadian government did not consider itself legally or morally bound to obey the UN Council's decree, or the UN General Assembly's 1981 resolution, which specifically requested that Canada and the other countries involved in the [uranium] cartel "take measures to prohibit their state-owned corporations, together with their subsidiaries, from all dealings in Namibian uranium" (Edwards 1983).

The assault on the environment and the lives of indigenous people by uranium mining pales in comparison to the crimes which accompanied aboveground weapon testing. To test their weapons, the United States, the Soviet Union, France, Great Britain and China secured isolated areas, oblivious to the ruin they would produce in aboriginal cultures and the ecological fabric of the region. The archetypal, most perfect embodiment of environmental racism, which set the pattern for all subsequent weapon testing was carried out by the United States in the Marshall Islands. The Marshalls consist of 29 low-lying coral atolls and five islands in an area of 357,000 square miles of the Pacific Ocean. In 1944, the US

wrested the islands from the Japanese and occupied them for the remainder of World War II. In 1947, the Trust Territory of the Pacific Islands was established by the United Nations which designated the United States as the administrator. The islands included in the trusteeship consisted of the Marshall Islands, the Caroline Islands (which include the islands of Kosrae, Pohnpei, Truck/Chuuk, Yap and Belau), and the Marianas Islands (which include Guam, Saipan and Tinian) (Salvador 1999). Article six of the Trust Agreement reads as follows:

> The administering authority shall:
>
> 1. foster the development of such political institutions as are suited to the trust territory and shall promote the development of the inhabitants of the trust territory toward self-government or independence as may be appropriate to the particular circumstances of the trust territory and its peoples and the freely expressed wishes of the peoples concerned; and to this end shall give to the inhabitants of the trust territory a progressively increasing share in the administrative services in the territory; shall develop their participation in government; and give due recognition to the customs of the inhabitants in providing a system of law for the territory; and shall take other appropriate measures toward these ends;
>
> 2. promote the economic advancement and self-sufficiency of the inhabitants, and to this end shall regulate the use of natural resources; encourage the development of fisheries, agriculture, and industries; protect the inhabitants against the loss of their lands and resources; and improve the means of transportation and communication;
>
> 3. promote the social advancement of the inhabitants and to this end shall protect the rights and fundamental freedoms of all elements of the population without discrimination; protect the health of the inhabitants; control the traffic in arms and ammunition, opium and other dangerous drugs, and alcoholic and other spirituous beverages; and institute such other regulations as may be necessary to protect the inhabitants against social abuses; and
>
> 4. promote the educational advancement of the inhabitants, and to this end shall take steps toward the establishment of a general system of elementary education; facilitate the vocational and cultural advancement of the population; and shall encourage qualified students to pursue higher education, including training on the professional level (Trusteeship).

Before the ink had dried, the US was forsaking all pretense of trusteeship. The tragedy commenced in February 1946. Commodore Ben Wyatt, US Military Governor of the Marshall Islands, approached King Juda and the 167 residents of the Bikini Atoll and asked if they would be willing to vacate their island temporarily for the "good of mankind and to end all world wars" (Guyer). Upon agreeing, the entire population was relocated to Rongerik Atoll, 125 miles away. Soon after, the US conducted Operation Crossroads in the Atoll. To test the effectiveness of atomic bombs against naval armadas, two bombs were detonated in proximity to a fleet of decommissioned vessels. Shot Able was detonated in the atmosphere above the vessels. Shot Baker was the first atomic bomb set off underwater. It produced an environmental catastrophe. The explosion jettisoned into the atmosphere the atomized coral reef and millions of gallons of water vapor, both now made radioactive by neutron activation, which contaminated the entire lagoon, the islands of Bikini Atoll and beyond. (In subsequent years, field teams from the University of Washington studied the web of life at Bikini, documenting the uptake of radionuclides by plants and animals and the increased concentration of radionuclides in feeders at the top of the various food chains.)

While their home was being decimated, the people of Bikini suffered. The US navy relocated them to Rongerik Atoll. Rongerik was one-sixth the size of Bikini and was uninhabited due to a lack of water. The food supply was poor. And to top it all off, a native tradition held that evil spirits roamed the island (Fretwell). Within months of arriving at their "temporary" home, the Bikinians were starving and begging to go home. Unaware at that time of the depth of their victimization, they had no idea that their idyllic home had been irretrievably despoiled. After Crossroads, between 1946 and 1958, the US used Bikini to test an additional 21 atomic and hydrogen bombs. The infamous Shot Bravo, a 15 megaton thermonuclear weapon, was detonated at Bikini on March 1, 1954.

In 1948, recognizing the inadequacy of Rongerik for sustaining life, the US temporarily relocated the Bikinians to Kwajalein Atoll. Six months later, in November, the entire community was resettled on their permanent home, Kili, in the southern Marshalls. The adversities they were forced to endure on Kili were many, including typhoons, forest fires, hunger, isolation and loss of their traditional diet and culture (Fretwell).

At the beginning of the 1970s, the US conducted "cleanup" operations on Bikini. In what can only be considered a human radiation experiment, the US permitted three extended families, consisting of just over 100 individuals, to resettle on Bikini in 1973. By 1975, regular radiological surveys revealed that newly planted crops were absorbing and concentrating radionuclides and that this contamination was being transferred to the inhabitants. When this information became public knowledge, the Bikinians filed a legal

suit against the US to force a complete radiological survey of Bikini. The US consented to this investigation, but it procrastinated for three years before starting. All the while, the people of Bikini were accumulating internal exposure. When alarming levels of cesium-137 were detected in their bodies in 1978, the people of Bikini were evacuated from their homeland.

The people of Bikini were not the only people in the Marshall Islands victimized by nuclear testing. In addition to the 23 tests at Bikini, 44 tests were conducted at Eniwetok Atoll. Eniwetok was initially selected as a test site in 1947. In September of following year, authorization was given by the US government to pay the Eniwetokees $515,360 for their islands. However, the Atomic Energy Agency refused to make payments without the native population providing legal proof of ownership (Fretwell). (How do traditional landholders provide legal proof of ownership?) Although nuclear testing began at Eniwetok in 1948 and the native population was relocated to Ujelang, no payment had been made through August 1951. Finally, in November 1956, US officials gave the Eniwetok people $25,000 cash and a $150,00 trust fund (Fretwell). Unlike the people of Bikini and Eniwetok, the native populations of Rongelap, Ailingnae and Utirik were not permanently resettled. They were temporarily relocated as fallout from Shot Bravo was passing over their islands but were then allowed to return.

Many disturbing events surround the Bravo test shot on Bikini. Prior to the test, the weather was miserable and the possibility existed that the test would have to be cancelled. At the last minute, the weather improved, but the winds were blowing in the direction of inhabited islands. Nevertheless, the test took place as scheduled. The fallout from this hydrogen bomb was horrific, and test personnel were rapidly evacuated from nearby islands. As the radioactive cloud drifted away from Bikini, it passed over Rongelap, 100 miles away. A radioactive snow of contaminated sand and coral fell to a depth of one and a half inches on the island. Utirik, 300 miles away, also was heavily contaminated. The people of these islands were not evacuated for three days. This incident was aptly characterized with these words: "These (and other) Pacific people were used as human guinea pigs in an obscene racist experiment — a particularly sharp snapshot of colonialism and the horrors wrought by the arrogant mindset which goes with it" (Peace Movement Aotearoa). This is not hyperbole. A report by the Brookhaven National Laboratory had this to say about Rongelap:

> Even though the radioactive contamination of Rongelap Island is considered perfectly safe for human habitation, the levels of activity are higher than those found in other inhabited locations in the world. The habitation of these people on the island will afford most valuable

> ecological radiation data on human beings (Fretwell).

Merril Eisenbud, then an official with the Atomic Energy Commission, offered this racist quip regarding Shot Bravo and the unique opportunity it created for studying radiation effects in the Rongelap people: "While it is true that these people do not live the way civilized people do, it is nevertheless true that they are more like us than the mice" (Taliman).

While recalling memorable proclamations of environmental racism, the following famous quotation needs to be enshrined. During the 1970s, when Micronesians began demanding independence, Walter J. Hickel, US Secretary of the Interior, asked Henry Kissinger his opinion on the subject. Kissinger replied: "There are only 90,000 people out there. Who gives a damn?" (Katosang).

Rosalie Bertell conducted research on the Rongelap people and provided this telling anecdote:

> The medical examination of the Rongelap people included many reports of "monster" and molar births. According to the people, they actually began to photograph these abnormalities, which at first they had hidden thinking it was their own fault to have such abnormal pregnancies. When the photographs were shown to American researchers, the pictures were seized. They burned them in front of the people saying: "This is what we think of your evidence." We heard this story from many different people on the Atoll (Bertell, February 1998).

Although buried in the scientific journals, evidence remains of the terrible toll of death and disease bequeathed to Marshall Islanders from nuclear testing. In exchange for their innocence, trust and powerlessness, these people received payment in the form of chronic illnesses, congenital diseases and malformations, miscarriages and stillbirths, thyroid problems, tumors and cysts, heart problems, reproductive problems, mental and neurological abnormalities, and adult onset diabetes (Bertell. February 1998).

In the last two decades of the twentieth century, the people of the island nation of Belau in the Caroline Islands worked to create a nuclear-free zone in Micronesia. Their sovereignty movement represented decolonization, demilitarization and denuclearization and was an affront to US interests in the Pacific. Richard Salvador of the Nuclear Age Peace Foundation wrote these insightful words of how nuclear colonialism is an enemy of democracy:

> The crucial issues to consider here, or in similar nation-building efforts, are those of democratic principles and military imperatives. Between 1983 and 1993, Belau peoples exercised their democratic right to freely express their common wishes in founding a nuclear-free island nation. In all of these democratic exercises, we said No each time. US military imperatives overrode all of those No's and undermined democratic practice; but this is not something new. Cultures of militarism and nuclearism are, by nature, cultures of secrecy. They erode openness and democracy and make indispensable a culture of death and terror which legitimizes militarism and production and use of weapons of mass destruction. The theory and practice of nuclear deterrence have been extremely hostile to democratic practice. National military strategies have often required the absence of free democratic thought while, on the other hand, a commitment to nuclear disarmament and demilitarization will allow communities to participate more fully in both the political sphere and civil society, in working to ensure a world free of the nuclear dangers that confront us (Salvador 1999).

A contributing factor to the erosion of democracy in America during the second half of the 20th century was government deception regarding atmospheric weapon testing in Nevada. Many of the lies referenced in this book took root and blossomed during the 1950s as a hedge against Americans discovering the extent of radioactive contamination spreading across their nation. While environmental studies in the Pacific were documenting the contamination of food chains at Bikini, nonstop detonations were illuminating the sky over Nevada. Even after strontium-90 was detected in dairy products and in the teeth of children, the government dodged accountability. Weapon testing took priority over the welfare of citizens of the homeland, and nuclear colonialism and environmental racism shredded democratic principles and ideals.

In the early 1950s, the government of the United States seized land belonging to the Western Shoshone and Southern Paiute peoples to create the Nevada Test Site. The story of this land grab is succinctly told by Kuletz:

> The Western Shoshone land base included the Nevada Test Site, Yucca Mountain, and beyond (actually 24 million acres). The 'legal' claim to the Nevada Test Site area stems from the 1863 Treaty of Ruby Valley, which is a peace and friendship treaty allowing settlers to travel through Shoshone territory; not to withdraw it from the Indian use. The treaty identifies the territory but does not cede the territory

> to any US political entity. In the 1970s the US government initially offered the Western Shoshone a sum of $26,145,189 to buy the land, but the money still sits in the bank. The Shoshone refuse to accept money for something they refuse to sell. Not taking 'no' for an answer, the US government, under the auspices of the Indian Claims Commission, proceeded to accept the money on behalf of the Western Shoshone so that it (the US government) could proceed with establishing title to the land. The Western Shoshone see this ruse as US usurpation of their land, an infringement on their sovereignty that threatens a fragile cultural identity and survival.

At the Nevada Test Site between 1951 and 1992, a total of 928 nuclear tests were conducted. Of these, approximately 100 were atmospheric detonations. According to Chief Raymond Yowell of the Western Shoshone: "We are now the most bombed nation in the world. The radiation has caused Shoshone, Ute, Navajo, Hopi Paiute, Havasupai, Hualapai and other downwind communities to suffer from cancer, thyroid disease and birth defects" (Taliman). In retrospect, it is apparent that precautions at the Nevada Test Site were inadequate for protecting these populations. Native Americans living off the land were not adequately informed that traditional sources of fresh water were contaminated and that grazing livestock were vulnerable to uptake of hazardous levels of radionuclides. In the late 1980s, the Department of Energy attempted to calculate radiation exposures from the Nevada Test Site. Doses were calculated for nine different lifestyle models (George and Russ). Invisible to this study were the unique lifestyles of the indigenous inhabitants and the additional routes of exposure to which they were vulnerable (Frohmberg *et al.*). For instance, Native Americans of the region routinely hunted and consumed small game such as wild rabbits. This vector concentrated iodine-131 in the thyroid glands of people in native communities and was passed on to nursing infants through breast milk (Russ *et al.*).

It is difficult to find the right word to characterize the raining down of radioactivity on Americans living downwind of the Nevada Test Site. For that matter, radioactivity was detected in the Midwest after the Trinity Test in 1944 and students at Rensselaer Polytechnic Institute in Troy, New York, measured fallout radiation after Shot Simon in 1953. Unbeknownst to the entire population of the United States, everyone was transformed into a downwinder, vulnerable to greater risks of radiogenic diseases. Clearly, to use the term "racism" to describe this type of victimization is inappropriate. Perhaps expressions such as "nuclear despotism" or "nuclear tyranny," or better yet "nuclear fascism", would be more apt for describing the contamination of a people by their own government or by government subsidized industries. The BIG question is who is profiting from all this oppression, disease and ruination of the environment. Certainly not the common man and woman. Then who and for what? Could the answer be so crass as for the

ruthless power of those sworn to an ideology of domination and the greed of a handful of industrialists, armament makers and energy company czars?

In lockstep with the environmental racism practiced by the United States, Britain conducted its nuclear testing in its former colony of Australia on the homeland of the Pitjantjatjara, the Tjarutja and the Kokatha peoples. Between 1952 and 1963, 12 atomic blasts were detonated and hundreds of minor tests involving radioactive material were conducted. Seven atomic bombs were set off at Maralinga and two others at Emu Field, both sites located in the Great Victoria Desert in South Australia. Three additional tests were conducted on the Monte Bello Islands off the coast of Western Australia. While developing the means of decimating cities, the British, with full support of the Australian government, helped decimate Aboriginal culture. Jim Green in his article "Radioactive Racism in Australia" documents the plight of the indigenous people at the time of British testing. According to Green:

> The general attitude of white settlers towards Aborigines was profoundly racist; Aboriginal society was considered one of the lowest forms of civilization and doomed to extinction. Their land was considered empty and available for exploitation — 'terra nullius.'

In his book *Fallout – Hedley Marston and the British Bomb Tests in Australia*, author Roger Cross succinctly describes the racism that underlied the British nuclear tests:

> Little mention was made of course about the effects the bomb tests might have on the Indigenous Australian inhabitants of the Maralinga area, a community that had experienced little contact with white Australia. In 1985 the McClelland Royal Commission would report how Alan Butement, Chief Scientist for the Department of Supply wrote to the native patrol officer for the area, rebuking him for the concerns he had expressed about the situation and chastising him for "apparently placing the affairs of a handful of natives above those of the British Commonwealth of Nations." When a member of staff at Hedley Marston's division queried the British scientist Scott Russell on the fate of the Aborigines at Maralinga, the response was that they were a dying race and therefore dispensable.

In harmony with the maltreatment of native populations that started during the early colonization of Australia, the British subjected native peoples to human rights abuse and racism, drove them from their tribal lands, incarcerated them in settlements and demonstrated indifference to their safety and welfare (Varney). In planning and executing

the tests, lands were seized from people who traditionally occupied them. At no time were these people, who had the most to lose from nuclear testing, consulted. The test sites themselves and vast tracts around them were permanently damaged, contaminated for millennia, and no compensation was ever provided. Rehabilitation efforts of the lands were a sham. What was once homeland was rendered radioactive wasteland.

These acts of environmental racism devastated Aboriginal culture and religion because of the wrenching disruption they produced between the people and their land. One can sense the depth of the impact from this observation by Robert Varney:

> To Aborigines the land is a spirit entity — a parchment on which their history is indelibly engraved and where special living places — sacred sites, have acquired significance as reminders of their past, a past also relived in the rituals of the Corroboree, the Dreamtime ceremonies, story telling and initiation. The deep Aboriginal belief that is centered on love and honor for the land that has nurtured them, is surely as profound and as worthy of respect as any other religion.

Varney adds to our understanding of the traditional lifestyle of the Aborigines:

> For thousands of years many Aboriginal tribes had lived and evolved in parts of Australia which, like the Great Victoria Desert that encompassed Emu Field and Maralinga, were areas that were amongst the harshest and most unforgiving territories on Earth. But they had learned to survive by adaptation, having developed a formidable knowledge of hunting, tracking, food gathering and ability to find water, and many whites that became lost and without resources owed their lives to Aborigines who befriended them. Aboriginal tribes lived a nomadic existence lest one place became over-exploited and its fragile environment irreparably damaged, their travels following well-worn routes chosen for their water holes, availability of game and "bush tucker."

Profound indifference to the distinctive lifestyles of the Aboriginal people was a root cause for the crimes that accompanied nuclear weapon testing. Those authorities overseeing the tests didn't bother to do their homework and were ignorant of Aboriginal culture, customs, numbers and distribution (Varney). Although the Monte Bello Islands were uninhabited, the tests there produced fallout that was blown east over Western Australia. Far more native people than assumed occupied the great swaths of this land. The fallout contaminated food and water sources and was responsible for producing radiation sickness and death.

On October 15, 1953, the Totem I test was detonated at Emu Field. It sent a radioactive cloud 250 miles northwest over Wallatinna and Melbourne Hill. A report penned in Britain in 1985 by the Royal Commission reviewing the British Atomic Tests in Australia concluded that wind conditions at the time of the test were unfavorable and a previous study had shown that such conditions would produce unacceptable levels of fallout. Further, the criteria established for carrying out tests failed to take into account possible contamination to aboriginal people living downwind (Green). The aftermath of this test was sudden outbreaks of sickness and death in downwind communities. Subsequent to the Totem I shot, 45 members of the Yankunyathjara were found to be dwelling a mere 170 kilometers from the blast. They reported being enveloped in a black mist soon after the explosion that rocked their land. As reported in a 1982 issue of *Cultural Survival Quarterly*, two days after the test the Yankunyathjara began to experience weakness and skin rashes, vomiting and diarrhea. By the third day, healthy children became blind. One person of the tribe died five days after the blast and more died within the next year. Within 15 years of the tests, aboriginals and white settlers who were exposed to fallout began suffering and dying from cancer (Rÿser).

In addition to being ill-informed of Aboriginal numbers, the test authorities failed miserably to control access by aboriginal groups to the test sites prior to the blasts or preventing them from entering contaminated areas after the tests. Barristers representing the Aborigines at the Royal Commission in 1985 characterized security prior to the tests as "an absolute farce, a total shambles" (Varney). Those who planned the tests at Maralinga were oblivious to the fact that the detonations were performed on tracts of land crisscrossed by ancestral migration routes. People routinely traveled over contaminated countryside after the tests. The slightest appreciation of the distinctive, traditional lifestyles of the Aborigines would have warned authorities that testing would put these people at risk. The people of the desert wore minimal clothing and no shoes. They lived off the land, dwelling in the open or in makeshift shelters. They hunted and gathered wild foods. Blanketing the area with radionuclides was guaranteed to be an act of genocide.

Measures to insure the safety of indigenous peoples were woefully inadequate. An insufficient number of native patrol officers were assigned the hopeless task of overseeing thousands of square kilometers. Signs warning of impending danger were erected at strategic locations, but these were written in English, a language that few Aboriginal people could read. Groups found living or migrating through areas likely to be contaminated were forcibly relocated. Prior to the tests at Maralinga in 1956-57, native groups were relocated at Yalata, several hundred miles from their tribal lands, where they remained until 1984. The trauma of dislocation and the loss of their traditional lifestyle resulted in the highest rate of alcohol-related illnesses and deaths of any Australian community (Barton). The

experience at Yalata for the Aborigines can easily be pictured in this anecdote:

> Speaking at a South Australian select parliamentary hearing in 1983, Hans Gaden who worked at the Yalata Mission in 1952 when he was responsible for moving the Maralinga Aborigines there, described the deterioration of living conditions during their stay. He claimed they should never have been moved South into territory which was so unlike their tribal lands, and lamented that 31 years later (they were still there in 1982) it was too late. He told how lack of an employment incentive (most wanted to work when moved there) made them lazy and how after 1967 when they could consume alcohol legally, they were ruined by drink, saying "Full-blooded Aborigines go to pieces after drinking alcohol." He talked of their taxi driver supplier saying "If I could have found that white man I would probably have shot him." Gaden summed up his feelings of Yalata when he said "That is what had become of the Aborigines from Maralinga. It almost makes me cry when I see them today. They are not the same people" (Varney).

Despite forced relocation, evacuation for the tests was later discovered to have been incomplete. On numerous occasions, native people were found roaming in contaminated areas, foraging for survival. In one well known incident, a family trekking through the desert was found camped inside a crater dug out by a nuclear blast. These "unplanned" exposures destroyed the health and lives of countless Aborigines.

Toward the end of the 1990s, a halfhearted display of cleaning up Maralinga was carried out, which according to a government document, was "aimed at reducing Commonwealth liability arising from residual contamination" (Green). Alan Parkinson, a nuclear engineer and whistleblower, had this to say about the Maralinga cleanup on ABC radio on August 5, 2002: "What was done at Maralinga was a cheap and nasty solution that wouldn't be adopted on white-fellas land" (Green).

In 2007, Green Audit published a health study of descendants of members of the British Nuclear Test Veterans' Association (Busby and de Messieres). The study looked at the veterans' children and grandchildren and investigated the rates for miscarriages, still-births, infant mortality, congenital illnesses and cancer. These rates were then compared with national statistics and with the descendants of unexposed controls. Richard Bramhall of the Low Level Radiation Campaign summarized the results of this study as follows:

> The findings are a challenge to conventional estimates of the health impact of radiation, because high levels of miscarriages, stillbirths

> and congenital conditions were found, though cancer was not greatly elevated.
>
> - Miscarriages were 2.75 times higher than expected,
> - Stillbirths were 2.7 times higher than expected,
> - The rates for congenital conditions are shocking. In the veterans' children they are 10 times higher than expected. The grandchildren have almost as much — an 8.35-fold excess, indicating that genetic damage is being passed down the generations at an unexpected rate. Conventional genetic theory would suggest that damage would be diluted in later generations. The study's results for congenital damage are in line with post-Chernobyl animal research that shows such effects persisting for up to 22 generations. The outlook for the future of the veterans' families is grim.
>
> None of the results correlates with "doses" recorded by the radiation film badge monitors that some of the servicemen were given to wear during the tests. Neither do the findings correlate with attendance at actual explosions, as the genetic damage is present in the descendants of men who served on test sites only between tests. These men were nevertheless exposed to fallout inhalation hazards. These two considerations strongly suggest that the cause of the health problems is chronic internal radiation, rather than acute external irradiation from the explosions themselves (Bramhall 2007).

Obviously, the findings of this study have implications for participants of weapon testing throughout the world and for all people who dwell on lands in proximity to the world's test sites. As this study suggests, the deployment of tactical nuclear weapons or limited nuclear war will produce horrific genetic effects in future generations. The noting of this consequence is absent from the Hiroshima Life Span Study.

Following the entrenched pattern established by other nuclear powers, France elected to detonate nuclear weapons in its colonies. As the Algerian War of Independence raged, France began testing atomic weapons in the Sahara desert at Reganne Oasis, 430 miles south of Colomb-Béchar. During 1960-1961, four atmospheric tests were conducted. Protests by surrounding African nations, and the fact that radioactivity from the tests had drifted north into France, forced continued testing underground. Radioactivity is still a hazard on land around the test site. The Algerian daily paper, *Liberté*, reported in June 2001 that early mortality of livestock is an ongoing problem (Schmid). At the cessation of testing, the French buried contaminated equipment and vehicles in the sand. Oblivious to the hazard, local inhabitants later uncovered the cache and sold it (Schmid). It has been reported that the health of Berbers, the indigenous people of North Africa, was adversely

affected by the testing (Rÿser). The French have persistently denied any adverse effects to people or the environment as a result of their testing program. Journalists allowed to study army archives in 1998, however, retrieved evidence that the tests created a major hazard to people downwind. According to an article that appeared in *Le Nouvel Observateur*, fallout from the 65 kiloton shot Blue Jerboise, the first Algerian test in February 1960, spread to the atmosphere above the former Fort-Lamy, what is now N'Djamena, the capital of Chad. A secret report written on July 15, 1960 stated that the air above the city immediately after the test was 100,000 times more radioactive than normal (WISE 1998). During the last test, French soldiers participated in maneuvers "under the cloud," marching to within 100 meters to ground zero 35 minutes after the blast. The purpose was to test protective materials and study the psychological response of the troops. The fear that gripped the soldiers was summarized in a report: "The psychological behavior of the soldier seems to be dominated by a psychose of fear, susceptible to become an obsession" (WISE 1998). Health studies of the thousands of participants in the operation were never undertaken. After the four atmospheric tests, French testing in Algeria moved underground. Between 1961 and 1966, 13 tests were conducted at In Ecker in the Hoggar mountains. Plutonium air dispersion tests were also conducted in the area.

When France began developing thermonuclear weapons, testing was relocated to economically dependent, French-occupied Polynesia. French Polynesia is comprised of 118 islands in the South Pacific, covering an area the size of Europe. Between 1966 to 1974, at the atolls of Moruroa and Fangataufa, 41 atmospheric tests were conducted. This was followed by 152 underground tests, the last of which was detonated in 1996. As in Algeria, a ruthless silence has been maintained by the French government regarding the effects of testing on downwind populations. Official pronouncements persistently portrayed French nuclear testing as "clean" and radioactive fallout had no effects on the health of the population of Polynesia (Braddock). This stance was part of a campaign of lies which became unraveled in a 478-page report presented to the French Polynesia Assembly on February 9, 2006. According to that report, the French suppressed for 40 years "damning proof" that each of the 41 atmospheric tests conducted between 1966 and 1974 dumped radioactive fallout on the populated island of Tahiti, 1,200 miles downwind of the test sites (Braddock).

As reported by World Information Service on Energy (WISE) in "French Nuclear Tests: 30 Years of Lies," contamination of unsuspecting innocents commenced with the first test:

> The first French Pacific nuclear test-explosion took place on Moruroa on July 2, 1966. Sixteen hours later, alarmist messages reached Vice-Admiral Lorain on the cruiser De Grasse: The cloud was more

> radioactive than had been thought, and stayed lower. The wind blew it towards Mangareva. A day later, a safety official from Mangareva sent a telegram: "Radioactivity not neglectable. Soil contaminated. Instructions asked for decontamination and food." Lorain only sent the scientific vessel la Coquille, and forbade the dissemination of information to the population, or to start safety directives. The doctor on board la Coquille, Millon, wrote a secret report, of which only two copies exist. The vessel arrived at Mangareva three days after the test. The first positive results (of measurement of radioactivity) are in fish and plankton. The fourth day the vessel reaches Rikitea, the largest village. Local products were already severely contaminated. Unwashed salads: 18,000 picocuries per gram, same level as at Chernobyl on the first day. After heavy rain, soil samples showed levels of 1,400 picocuries per gram, a still heavy contamination. Nothing was forbidden (except to disseminate information), nobody was warned. Millon wrote: "The population [was] completely unaware, carefree and show[ed] no curiosity" (WISE 1998).

Other damning revelations surfaced about French conduct in the aftermath of the the first test in the Pacific. A French government minister was observing the detonation from a nearby island in the Gambier group. An unexpected shift in the wind forced his immediate evacuation by plane. The inhabitants of the island were left behind and not informed of the hazard (Kleiner). As the fallout cloud approached the island of Mangareva, soldiers watched children playing in the sand at the beach. Fully aware that radioactivity was approaching the island, the soldiers gave no warning to the people. As characterized in "French Nuclear Tests: 30 Years of Lies:" "To warn the parents would mean warning the world France was going to poison an inhabited island. So they kept their mouth shut" (WISE 1998). A report presented to the French Polynesia Assembly in February 2006 contained invaluable insights into how France attempted to hide the incident. Research by the non-government Commission of Independent Research and Information on Radioactivity proved that external exposure to radioactive fallout in the Gambier Islands was twice the official levels later published (Braddock).

The same pattern of contaminating indigenous inhabitants and keeping silent continued during further tests in September 1966. Heavy rains contaminated the islands of Tureia and Mangareva. Measurements of the radioactivity in rainwater sampled from Mangareva reached 100,000 Becquerels per liter (WISE 1998). The military took no action to protect the exposed population. According to one officer, the fall of radioactive rain "necessitates a strengthening of the secrecy" (WISE 1998). The special vulnerability of the native Polynesians, and their potential for serving as a damning study group further down

the road, were known to test authorities:

> Four islands with 1,200 inhabitants were threatened with radioactive fallout: Reao, Tureia, Pukarua and especially Mangareva with 600 persons. What to do? It became an obsession for the atomic patrons. To evacuate them would be the best, they were advised by the Radiological Safety Service (SMSR). But then the media would know: for political and psychological motives this was out of the question. The SMSR experts knew the Polynesians were extremely vulnerable to radiation effects. As they wrote: "This population has special characteristics: isolated, an important fraction is less than 15 years old, pregnant women, elderly people." "Higher genetic risks than an average European population" (WISE 1998).

Between 1962 and 1997, the French employed 15,000 Polynesians to work for the atomic testing program. Most jobs were menial such as working in kitchens or doing construction. But other jobs were hazardous, necessitating work that resulted in substantial radiation exposure. Native Polynesians had no framework for understanding such concepts as "radiation" and "contamination" (Kleiner). Consequently, they had no way of assessing the danger in which they were placed. As related in the documentary *Moruroa and Us*, two Dutch social scientists, Pieter de Vries and Hans Seur, interviewed 737 former test workers (Kleiner). When hired, 73 percent were unaware where they would be working. Ten percent of the work force was 17 years old or younger when they were first hired. Forty-one percent reported that at some point in their employment they had worked in contaminated zones. Of these, 14 percent reported that handling contaminated equipment was part of their job. At times no protective clothing was available. At other times, they were forced to remove the clothing due to the sweltering heat. Often they conducted their work wearing nothing more than t-shirts and shorts. Fifty percent of workers reported either being unfamiliar with personal radiation detection dosimeters or were never issued them (Kleiner). As a consequence, there is no record of exposures to this population of workers and no basis for financial compensation for work-related radiation-induced illnesses or for help in paying for medical treatment. The survey did reveal that 7.4 percent of people employed at the test site had physically disabled children and 2.4 percent had mentally disabled children. Being unfamiliar with risks possessed by environmental contamination, the native work force unknowingly injured itself. For instance, Kleiner describes the following:

> The practice of frequently altering the boundaries of contaminated zones contributed over the course of time to the prohibited area not being taken seriously. In line with their cultural traditions, Tahitians often did not observe the restrictive rules. For example, fishing in the

> Moruroa lagoons was prohibited, but 55 percent of those interviewed stated they ate fish caught there. Fishing and the consumption of fish are an important part of Polynesian culture, and no fresh fish was available from the canteens.

Until 1998, native workers who became ill while working at the nuclear sites were treated at military hospitals. As a consequence, patients were prevented from later acquiring their medical records. Evidence exists that the rate of cancer in Polynesia increased subsequent to French weapon testing (Kleiner). By one account, the normal incidence of cancer in Polynesia is 17 percent. Among former Moruroa workers at the test site, 34 percent have cancer (Kleiner). In *Moruroa and Us*, the statistic was presented that 25.7 out of 100,000 Polynesian women contract thyroid cancer while the ratio is only 4.8 per 100,000 in France. Unusually high incidence of leukemia is beginning to appear in the population as well (Kleiner). Racial discrimination is reported as being a factor in the recognition of test site-related illnesses. Dr. Gilles Soubiran, an intern at Territorial Central Hospital in Tahiti relates the following:

> I know of one case dealing with a civilian inspector who contracted cancer and was acknowledged as a cancer victim. His driver, with a lesser social status, received over many years perhaps the same dose of radiation and likewise contracted cancer. He was, however, refused recognition as a cancer victim (Kleiner).

There is no end to the environmental catastrophe created at nuclear test sites. A perfect example occurred in March 1982. The cyclone William ripped up a layer of asphalt, under which was buried plutonium. The storm scattered 10 kilograms of the radionuclide over Moruroa. At the time 2,000 workers at the test site were stationed there. A decontamination project took five years to complete (Kleiner). What decontamination means under the circumstances is a debatable question.

The pillaging of the lands and lives of indigenous peoples by nuclear colonialism and environmental racism is perfectly caught in this observation by Kleiner:

> Prior to the commencement of atomic testing, Tahiti was a sleepy paradise whose people on the whole lived in harmony with nature and in accord with the laws of its thousand-year-old culture. Within 40 years, Tahiti was catapulted into the modern era through changes brought on by the atomic tests. Cultural identity was lost; young people do not even speak the language of their fathers and grandfathers

> and no longer understand the old culture. But neither do they have any prospects in the modern era. With the end of the tests, the largest employer has left, and France will end its massive financial support in 2006. Future social conflicts can already be foreseen in the slums of Tahiti's capital, Papeete, and its neighboring city of Faaa.

The Soviet Union, like the United States, tested nuclear weapons within its own borders and rained down radioactive fallout on its own people. Of 715 nuclear tests, 467 were conducted at the Semipalatinsk Test Site in northeast Kazakhstan. Of these, approximately 116 were atmospheric tests of atomic and hydrogen bombs. Another 224 tests were conducted on the islands of Novaya Zemlya, an archipelago in the Arctic Ocean north of Russia. The remaining 24 tests were located at other sites in Russia, Kazakhstan, Ukraine, Uzbekistan and Turkmenia. Semipalatinsk Polygon, or Semipalatinsk-21, was constructed in the late 1940s by slave laborers transported from the Gulag. According to James Lernager in his article "Second Sunset - Victims of Soviet Nuclear Testing," the test site was ringed by farms and ranches and hundreds of thousands of people lived within a 50 mile radius. Says Lernager: "The residents of eastern Kazakhstan may have received more radiation, over a longer period of time, than any other people on Earth." He then continues:

> Occasionally, some of the largest towns directly bordering the Polygon would be hurriedly evacuated by military personnel before a test. Even then, however, 30 to 40 young adults would be ordered to remain behind and take cover in houses and barns. Those who were evacuated returned weeks later to an apocalyptic landscape strewn with damaged homes and dead animals; those who had been forced to stay were dazed, weak, and feverish, and soon exhibited signs of acute radiation sickness. Most have since died.

A health crisis plagues the area. As many as 400,000 adults and children were made sick by radiation (Thompson). Birth defect rates are 10 times those of Europe, America and Japan (Thompson). Babies are routinely born with severe neurological and physical defects. Rates of death and disease are staggering, with inordinate occurrences of immune system disorders, leukemia, anemia and cancer. With water and food sources contaminated, the death rate from disease is triple that in other parts of the former Soviet Union (Thompson). Many people are afflicted simultaneously with a number of rare diseases (Lernager). From the time of testing, third-generation newborns have been found to have higher rates of chromosome abnormalities than those found in the first two generations (Lernager). As after Chernobyl, civilian doctors were forbidden to enter into the medical records of their patients any illnesses caused by radiation exposure. Officially, the Semipalatinsk region has

the lowest rate of cancer in Kazakhstan (Lernager). But the director of the Oncology Hospital in the area estimates that at least 60,000 people died from radiation-induced cancer (Lernager). In the village of Seriqkaisha, 20 miles from Semipalatinsk, almost every family is afflicted with some type of radiation-induced illness (Chance). Various types of deformities are common. The suicide rate in the region is one of the highest in the world (Chance). In the village of Dolon, radiation produced a high incidence of cancer, birth defects, nervous system disorders and immunological deficiencies (Makhijani 1999).

Between 1955 and 1990, the USSR tested nuclear weapons in the Arctic at Novaya Zemlya. In addition to typical atmospheric and underground tests, they conducted three underwater tests. Other so-called "peaceful nuclear explosions" were detonated in the 1980s for seismic studies, mining, experiments in diverting rivers and attempts to extinguish oil-field fires. This testing contaminated vast tracts with radioactive fallout. The impact to health of indigenous people from nuclear testing is not known. However, an association is expected between testing and diseases typical of radiation exposure at Chukotka, northern Yakutiya, Kolguyev Island and the Kola Peninsula (Dallmann). The indigenous people affected include the Nenets, Avars, Sami, Vepsians, Karelians and Komi.

Both inside and outside Russia, the Arctic is home to some four million inhabitants. Indigenous peoples form approximately one-third of this population. Fallout from nuclear testing contaminated the lichen-caribou-man food chain, making subsistence hunting a hazard to health. The risk borne by circumpolar peoples of increased incidence of radiogenic diseases was compounded by contamination from Chernobyl and radioactive pollution from nuclear reprocessing facilities in Europe. This was revealed in a 1998 study by the Arctic Monitoring and Assessment Program located in Oslo, Norway (WISE 1999). Four hundred scientists and administrators assessed the health and environmental impact of nuclear pollution in the eight countries that rim the Arctic: Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden and the United States. The study established that, between contamination of reindeer and "unique features of Arctic terrestrial and freshwater ecosystems," indigenous peoples were particularly at risk for radiation-induced illnesses. Among this population, some groups are among the most exposed people in the world. For instance, in Norway, reindeer meat was found to contain 500 - 2,500 becquerels of cesium-137 per kilogram. This was the primary reason why indigenous people of the area had levels of internal contamination 50 times above the norm (WISE 1999). To serve as a basis of comparison, the Japanese government has established as a standard that the maximum concentration of cesium in food cannot exceed 370 Bq per kg (WISE 1999).

Since 1964, the People's Republic of China has conducted 45 nuclear tests at Lop Nur, located in western China in the Xinjiang Uighur Autonomous Region. This densely

populated area is the ancient cultural center of eastern Turkestan and is the homeland of the Uighur people. To these local inhabitants, nuclear testing created a nightmare from which they have yet to emerge. The successive radioactive fallouts from the tests contaminated drinking water and food supplies and are thought by local observers responsible for the deaths of millions of animals and more than 200,000 people (SOTA). Official government figures are not available to substantiate this claim, but the Chinese government has conceded that deaths did occur (SOTA). Local people claim that since 1975, the incidence of leukemia has increased sevenfold and the incidence of cancer of the esophagus between seven- and eight-fold. Pregnancy and birthing problems have increased by similar rates (SOTA). In 1988, allegations were made that 20,000 deformed children lived in areas near Lop Nur (SOTA). Fallout from Chinese nuclear tests drifted over Kazakhstan, Kyrgyzstan and Tajikistan, but the human and ecological impact has not been systematically assessed.

In addition to uranium mining, China has constructed in Tibet facilities for producing nuclear weapons. The environmental impact from these activities has been horrendous. Gonpo Thondup addressed this issue at the World Uranium Hearing in Salzburg, Germany, on September 14, 1992. Thondup, who escaped from Tibet to India in 1987, visited two nuclear weapons production departments code numbered 405 in Kyangtsa and 792 in Thewo, Amdo region (Central). In his statement, he offered the following observations:

> The effects of experiments and waste from 792 and 405 have been devastating. Before 1960, in this region of Amdo, harvests were plentiful and domestic animals healthy. Now the crop yield has shrunk and people and animals are dying mysteriously, and in increasing numbers. Since 1987 there has been a sharp rise in the number of deaths of domestic animals and fish have all but vanished. In the years of 1989 and 1990, 50 people died in the region, all from mysterious causes. Twelve women gave birth in the summer of 1990, and every child was dead before or died during birth. One Tibetan woman, Tsering Dolma (aged 30), has given birth seven times and not a single child has survived.
>
> The people living near departments 405 and 792 have experienced strange diseases they have never seen before. Many local people's skin turned yellowish and their eyesight has been affected seriously. The local populace reported strange memory losses and many babies are born deformed. The people of the area are desperate and can only turn to religion and local doctors who have no knowledge of the uranium mines or of the nuclear plants nearby (Dekhang).

Little is known of the human and environmental costs produced by the weapon testing of other countries. India was detonated five or six underground tests at Pokhran. Pakistan detonated between three and six weapons at Chagai Hills. North Korea detonated one weapon, deemed a failure by the CIA, at Hwadae-ri in October 2006. Either Israel or South Africa, or perhaps the two countries working jointly, are likely responsible for detonating a nuclear weapon in the Indian Ocean on September 22, 1979 in what is now referred to as the Vela Incident.

The destruction of indigenous cultures forever silences ancient wisdom. This might serve to explain the senseless radioactive contamination of the Earth that we are witnessing today. Perhaps the New World Order can only take root on desecrated lands. In this vein, deep insight may be garnered from this aboriginal voice:

> The Great Spirit has instructed us that we have a sacred bond with our Mother Earth and an obligation to the creatures who live upon it. This is why it is disturbing that the federal government and the nuclear power industry seem determined to ruin forever some of the few lands we have left (Thorpe).

The intractable problem of the disposal of radioactive waste completes the tragedy of humankind's nuclear odyssey. For the selfish, short-term gain of a few, the Earth and all life has been yoked with a burden that will take millennia to dispel. When the nuclear age was in its infancy, the problem of caching radioactive waste was recognized. Rather than solving the problem before creating millions of tons of the stuff, the nuclear powers raced to exploit the atom in the belief that technology would catch up and solve the problem. A half-century later, radioisotopes never before present on the Earth are aloft upon the winds and floating in the waters. The terrible mentality that grips the earth finds this state of affairs acceptable and makes every effort to perpetuate it.

To date, this terrible mentality has only conceived of one storage solution: to permanently annex lands once belonging to aboriginal peoples and cordon off forever these regions as zones of permanent sacrifice. Witness here the logical end of every act of nuclear colonialism: the transformation of homelands into wastelands. The argument is often made that humankind must accept the tradeoff, that to reap the benefits of nuclear power or political security we all need accept the burden posed by radioactive waste. This argument is fallacious. Who is really profiting from this state of affairs? In the long run, who benefits from a contaminated Earth littered with poisoned water, poisoned air and poisoned creatures? Some amongst us either must be plagued by a primitive mentality that cannot realistically assess the damage already done or they somehow stand to benefit from the state of affairs they created. Such pondering, as this whole book intends, points to

hearts of darkness, hearts working, both intentionally and unintentionally, to consume us all.

In the United States, transuranic waste from the nuclear weapons program began arriving in 1999 at the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico. Radioactive waste from commercial nuclear power plants is tentatively scheduled to start arriving at Yucca Mountain, inside the Nevada Test Site, in 2017. This despite heated controversy that the facility is ill-conceived and located in an geologically unsuitable area. [The Bow Ridge fault runs directly beneath the site, and since 1976 there have been 621 seismic events within a 50-mile radius of magnitude 2.5 or greater on the Richter scale (Attewill)]. As an interim measure, "temporary" storage sites have been sought on lands belonging to Native Americans. In 1987, the Office of Nuclear Waste Negotiator was created by Congress for the purpose of opening a federally monitored retrievable storage site for high-level nuclear waste. As related by Kevin Kamps in "Environmental Racism, Tribal Sovereignty and Nuclear Waste," the nuclear negotiator proceeded to contact every federally recognized tribe in the country, offering huge sums of money to first consider and then ultimately host a dump. Of the hundreds of tribes contacted, only about two dozen were eventually "courted" by the negotiator (Kamps). During the process the nuclear negotiator, David Leroy, suggested that Native Americans would be excellent stewards of the nation's radioactive waste due to their reverence for the environment and long tradition of valuing the land:

> The heritage which reveres the environment often can perceive, in very subtle and very significant ways, how necessary and how appropriate, and how environmental the call for the safe storage of spent fuel is for many generations of Americans yet unborn — native and non-natives. That environmental sensitivity is a great asset because we are asking to create an environmentally sensitive facility for an environmentally sensitive mission (Erlich).

The ploy to use Native American impoverishment as a lever to acquire a dump site did not fool anyone. Grace Thorpe in "Radioactive Racism? Native Americans and the Nuclear Waste Legacy" had this to say:

> The US government targeted American Indians (for nuclear waste disposal) for several reasons: their lands are some of the most isolated in North America, they are some of the most impoverished and, consequently, most politically vulnerable and, perhaps most important, tribal sovereignty can be used to bypass state environmental laws. How ironic that, after centuries of attempting to destroy it, the US government is suddenly interested in promoting American Indian sovereignty — just so it can dump its lethal garbage! All Indian treaties

> and agreements with the US government have been broken. Today's Indians remember yesterday's broken promises. The Indians cannot trust the federal government and certainly cannot trust the nuclear industry whose driving force is monetary profit.

Due to fierce community resistance within the targeted tribes, the nuclear negotiator failed in his mandate to acquire land for a dump. As a consequence, the Office of Nuclear Waste Negotiator lost its funding and was dissolved by Congress in 1994. The hope of exploiting Native Americans' economic vulnerability, however, did not end there. A consortium of 33 nuclear power utilities began exerting pressure on the Mescalero Apache Tribe in New Mexico. When this came to naught, a coalition of eight utilities under the name of Private Fuel Storage began working on the Skull Valley Goshutes in Utah. Over the years, the nuclear power establishment had targeted 60 Native American communities as possible sites for a waste repository. Fifty-nine of these had successfully rebuffed their overture (Kamps 2006). But the Skull Valley Goshutes became the one exception. The small tribe of approximately 125 individuals was economically depressed and already encircled by toxic polluters. Kevin Kamps paints a clear picture of the tribe's plight:

> The reservation is already surrounded by toxic industries. Magnesium Corporation is the nation's worst air polluter, belching voluminous chlorine gas and hydrochloric acid clouds; hazardous waste landfills and incinerators dot the map; with a name straight out of Orwell's 1984, Envirocare dumps "low level" nuclear waste in the next valley and is applying to accept atomic trash hundreds of times more radioactive than its present license allows. Dugway Proving Ground has tested VX nerve gas, leading in 1968 to the "accidental" killing of 6,400 sheep grazing in Skull Valley, whose toxic carcasses were then buried on the reservation without the tribe's knowledge, let alone approval. The US Army stores half its chemical weapon stockpile nearby, and is burning it in an incinerator prone to leaks; jets from Hill Air Force Base drop bombs on Wendover Bombing Range, and fighter crashes and misfired missiles have struck nearby. Tribal members' health is undoubtedly adversely impacted by this alphabet soup of toxins. Now PFS wants to add high-level nuclear waste to the mix (Kamps 2001).

Tribal Chairman, Leon Bear, had this to say of the tribe's plight:

> We can't do anything here that's green or environmental. Would you buy a tomato from us if you knew what's out here? Of course not. In

> order to attract any kind of development, we have to be consistent with what surrounds us (Kamps 2001).

In 1996, without approval by the tribal council, Bear signed a lease agreement with Private Fuel Storage. The agreement opened the door for the "temporary" storage of 40,000 tons of commercial high-level radioactive waste. This amount represented approximately 80% of the commercial irradiated fuel in the US up to the end of 2004 (Kamps 2005). Aside from the three-member executive committee of the tribe, no one else was informed as to the amount of money involved in the transaction. Says Kamps: "Estimates of the secretive payoff to the tribal council range from 60 to 200 million dollars." The Nuclear Regulatory Commission, which licensed the dump, ruled that the dump did not violate principles of environmental justice because the tribe was being well rewarded financially and the dump represented "no disproportionately high and adverse impacts on low income or minority populations" (Kamps, 2001). Eventually, the scheme of Private Fuel Storage came to naught. On September 7, 2006, the US Bureau of Land Management rejected the proposed plans to ship commercial radioactive waste across the country to Skull Valley. The US Bureau of Indian Affairs also interceded, rejecting the lease agreement signed privately by Leon Bear. With Skull Valley kaput, the last remaining hope for a permanent repository for the nation's commercial radioactive waste is Yucca Mountain, sacred land of the Western Shoshones and legitimate owners of the land as outlined in the Treaty of Ruby Ridge.

The nuclear behemoth's radioactive waste is subjugating the entire globe under nuclear colonialism and marginalizing all of humankind. With the Earth our shared home, all acts which contaminate the Earth are acts of environmental racism, perpetrated by the nuclear policymakers against everyone else. In the 16 countries where uranium is mined, millions of tons of radioactive mill tailings remain uncovered, allowing radionuclides to be swept into the air or washed into waterways. British Nuclear Fuel's Sellafield reprocessing facility dumps radioactive waste directly into the Irish Sea. Cogéma's reprocessing facility at La Hague in France dumps one million liters of liquid radioactive waste, the equivalent of 50 waste barrels, into the ocean every day (Greenpeace 2000). Russia has scuttled decommissioned naval vessels, sending loaded nuclear reactors to the ocean floor. Between 1949 and 1956, the nuclear weapons complex at Chelyabinsk in the former Soviet Union dumped 96 million cubic meters of radioactive liquid into the Techa River (WISE 1990). The facility also pumped 120 million curies of radioactivity into Lake Karachay. Standing on the shoreline, a person would receive a lethal dose of 600 roentgens in one hour (WISE 1990). Water levels at the lake have been steadily dropping for years and parts have dried out completely. Winds have lofted radioactivity into the air, spreading contamination around the planet. At the Hanford Reservation in Washington state, one third of the 177

tanks holding 54 million gallons of high-level waste are leaking. Nearby underground aquifers contain an estimated 270 billion gallons of contaminated water (Wolman). Also at Hanford, 40 billions gallons of contaminated water was dumped directly into the soil and storage ponds are leaking. As a result, radioactive waste is migrating into the Columbia River. At the former West Valley reprocessing facility 50 miles south of Buffalo, New York, radioactive and chemical wastes continually leach into Cattaraugus Creek. For 18 miles, the creek flows along the Cattaraugus Reservation of the Seneca Nations of Indians before emptying into Lake Erie (Concerned Citizens). Cesium-137 and strontium-90 contaminate soil and groundwater in and around the 3,345 acre site. The Department of Energy is attempting to change its regulations to declassify high-level radioactive waste into "waste incidental to reprocessing." Under this new classification, environmental contamination would be allowed to remain in the ground (NIRS 2004). DOE favors covering up contaminated areas with concrete and walking away (Coalition). This despite the fact that a 1996 study by DOE calculated that within 500 years radionuclides from West Valley would begin migrating into the Great Lakes Watershed (Coalition).

An entire book on the subject could be written, but the point need not be belabored. A profound disconnect exists between those people knowledgeable about the hazards of radiation and those responsible for making day-to-day decisions on nuclear waste management. As a result, radioactivity is being flushed into ecosystems around the world with total abandon as to the consequences. This is a doomsday scenario produced by profit-seekers and government bureaucrats unwilling or unable to appreciate the environmental consequences of their actions and their ignorance.

If and when the Yucca Mountain repository opens, large sectors of the United States will come under the dominion of nuclear colonialism. By 2010, 63,000 metric tons of commercial irradiated fuel will be in temporary storage at nuclear power plants around the country. To reach Nevada, this material will require transport across 44 states. This scenario sets the stage for "mobile Chernobyls." A single transport accident could be catastrophic. An alternative scenario, admittedly of low probability, is even more disturbing. In the event of major social upheaval due to war or natural catastrophe, services may be severely interrupted. Such unforeseen circumstances might force the abandonment of the spent nuclear fuel currently stored at the nation's nuclear power plants. One hundred and three zones of sacrifice would be created, remaining lethal to all life for hundreds of thousands of years. With the passage of time, this neglected waste would leach from storage and migrate into the environment. With nuclear reactors located near large volumes of water, radioactivity will be widely dispersed around the globe. This is a not an unreasonable epitaph for the nuclear age.

When hearing of the plight of indigenous people overwhelmed by nuclear colonialism and environmental racism, uninformed or indifferent Americans may blithely carry on their lives, failing to recognize their kinship to these marginalized people. Take as an example the nuclear weapon hydrodynamic testing, conducted at Lawrence Livermore Nuclear Laboratory (LLNL) 50 miles east of San Francisco. Since 1961, weapon engineers have performed these open-air tests to gauge the reliability of the metal pit primaries within nuclear weapons. These cores consist of a sphere of fissionable material surrounded by a jacket of high explosives. When detonated, the shaped charge compresses the highly enriched uranium or plutonium sphere in such a geometry as to initiate a chain reaction. At GlobalSecurity.org, the design of the devices being tested are described in this way:

> Hydroshot tests are conducted to test the hydrodynamic performance of the shaped explosives used in the ordnance. The explosive device used in the hydroshot testing comprised an explosive charge shaped as a hemisphere, about half the size of a basketball and weighing from 1-3 kg (2.2 to 6.6 lb). The explosive charge was surrounded by a DU ring about 1-2 inches in height and weighing about 22 kg (48.5 lb). The purpose of the DU ring was to simulate the hydrodynamic conditions in a fully spherical weapon (GlobalSecurity.org, Hydrodynamic).

As to the purpose of hydrodynamic testing, this is summarized as follows:

> In these types of experiments, test assemblies that mock the conditions of an actual nuclear weapon are detonated using high explosives. In hydrodynamic testing, non-fissile isotopes, such as uranium-238 and plutonium-242, are subjected to enough pressure and shock that they start to behave like liquids (hence the 'hydro' in hydrodynamic). Radiographs (x-ray photographs) can be used to obtain information on the resulting implosion; computer calculations based on these test results are used to predict how a nuclear weapon would perform.
>
> Multiple view hydrodynamic testing (experiments to look at the flow of adjacent materials as they are driven by high explosives) and dynamic testing (experiments to study other effects of high explosives), combined with computer modeling, provide the only means of obtaining design data in the absence of nuclear testing.
>
> Hydrodynamic tests and dynamic experiments have been an historical requirement to assist in the understanding and evaluation of nuclear weapons performance. Dynamic experiments are used to

> gain information on the physical properties and dynamic behavior of materials used in nuclear weapons, including changes due to aging. Hydrodynamic tests are used to obtain diagnostic information on the behavior of a nuclear weapons primary (using simulant materials for the fissile materials in an actual weapon) and to evaluate the effects of aging on the nuclear weapons remaining in the greatly reduced stockpile. The information that comes from these types of tests and experiments cannot be obtained in any other way (GlobalSecurity.org).

These tests, conducted at Site 300, 15 miles southeast of LLNL, have produced one of the most contaminated areas in the United States. In 1990, the Environmental Protection Agency designated Site 300 as a federal "Superfund" site requiring remediation. The soil and groundwater are polluted with a mixture of chemical and radioactive wastes comprised of solvents, tritium, depleted uranium, heavy metals and high explosive residue (Tri-Valley). In the past, LLNL has been limited to exploding 1,000 pounds of uranium annually. In April 2007, an application to increase this amount to 8,000 pounds was submitted to the San Joaquin County Pollution Control Board and subsequently approved.

Relevant to the thesis of this book is the fact that during hydrodynamic testing, the depleted uranium metal in the test assemblies is aerosolized in the explosions into ultrafine spheres of insoluble ceramic uranium oxide. This material is identical to that released on the battlefield by uranium munitions. Thrust airborne, this material is ferried by the winds into the Bay Area and Central Valley. Seven million people live within a 50-mile radius of Site 300, and 5,500 new homes are to be built within a mile of the testing range (Tri-Valley). Given the demographics, there is a "coincidence" that needs pondering. Marin County, just north of San Francisco, has one of the highest incidences of breast cancer in the world! A study published in Breast Cancer Research had this to say:

> From the inception of the Surveillance, Epidemiology, and End Results (SEER) national cancer registry network in 1973, Marin County, California, a small county near San Francisco, has consistently reported higher than average annual incidence rates of breast cancer. Averaged from 1973 to 1999, Marin County reported the highest overall breast cancer incidence rate of the 199 counties included in the SEER database (based on the SEER 9 November 2001 submission released April 2004). In recent years, reports of rapidly increasing breast cancer rates in Marin County attracted public and media attention. These reports suggested that overall age-adjusted incidence rates of invasive breast cancer in non-Hispanic white (nHW) women living in Marin County had increased approximately 60% between 1990 and 1999, as compared to 5% in surrounding regions. These

> trends have resulted in Marin County having one of the highest incidence rates reported in the world and have prompted public and scientific concern (Phipps *et al.*).

In conclusion, our ears need to open to the story of the Nuclear Age as recounted by displaced and exploited aboriginal people around the globe. Their narrative gives new perspective to current events, for it unabashedly reveals that the testing and deployment of uranium weapons in the Middle East is just another incarnation of nuclear colonialism. In the quest to appropriate oil reserves rightfully belonging to others and to remake the region into one friendly to the New World Order, the United States is experimenting with the subjugation of populations by blanketing their homeland with radioactivity and depopulating the region through radiogenic sickness and genetic deformities. That this method of warfare is directed primarily against Afghani and Arab Muslims makes this campaign a blatant expression of environmental racism. Conventional weapons could easily have accomplished all the goals so far achieved by DU weaponry. But uranium weapons produce heightened effects. They significantly enhance the kill ratio per weapon both in space and in time. They produce terror in the population. And they render the environment inhospitable to its native inhabitants.

If we are not heedful, nuclear colonialism may ultimately culminate in the subjugation of all of mankind. Nuclear weapons may be the instrument of choice for herding terrified humanity, terrified by limited nuclear wars or terrorist threat, into embracing the new order of a world government. The creators and sustainers of the infernal weapons will posture as the deliverers of eternal peace. In exchange for enduring safety and security, the small price demanded will be the surrender of our liberty.

No different from the devotees of Baal in antiquity, the devotees of nuclear and radiological weapons will be memorialized as nothing other than worshippers of false gods, dutifully and joyfully throwing human unfortunates into blazing fires to serve as sacrificial offerings. The religion of the Cult of Nuclearists will be reconstructed as one in which aggrandizement over God was repeatedly asserted through the dark and sacred rite of unleashing over the surface of the Earth the Creator's secret energy bound within matter. By their deeds, the members of this brotherhood will be known: how they walked upon the Earth in arrogance, intoxicated with their own power; how living things seemed paltry in their eyes so as not to sway them from sickening whole populations with their radioactive poisons and degrading the life-sustaining capacity of nature; how they did not flinch from cataclysmic warfare that decimated civilizations, corrupted the gene pool of their species and made the surface of the Earth a habitat of pestilence and decay.

17

The Mentality of Genocide

"At Nuremberg after the Second World War, there was an attempt to hold individuals and groups accountable for their role in killing. There can be no nuclear Nuremberg; hope lies only in establishing responsibility for genocide prior to its occurring — responsibility for participating in a genocidal system and a genocidal process."[1]

Nuclear and radiological weapons are a blemish on the Earth, an insult to Life. The vast majority of human beings abhor these monstrosities. So why do they endure?

Earth's liberation from nuclear weapons is obstructed by the Cult of Nuclearists and the ideology of genocidal terror erected by this cabal. Over decades, a closed brotherhood of politicians, warriors, scientists, technicians, and businessmen systematically created and refined weapons of unlimited destructiveness. In concert with this buildup, they evolved an ideology that the threat of assured destruction to any aggressor, coupled with the threat of radiological contamination of the Earth, was the modern basis for security, peace, and safety. The terrible power of this cult over world affairs, projected by their hellish weapons and frightening ideology, gradually rendered impotent all other viable methods for achieving

[1] This chapter is a synopsis of ideas originally conceived and published by Robert Jay Lifton and Eric Markusen in their book *The Genocidal Mentality: Nazi Holocaust and Nuclear Threat*. New York: Basic Books, 1990. Credit is due to them for the fundamental ideas presented here relating to the genocidal mentality, the history of the Nazi genocidal machine, the intent to commit genocide inherent in deterrence ideology, and the parallels between Nazi ideology and nuclearism. All quotations in this chapter, unless otherwise referenced, are from *The Genocidal Mentality*.

peace. Their campaign paved the way for centralized control of all human affairs whereby a relatively small number of people hold the rest of the world hostage to their agenda.

The first conquest of this Fraternity of Domination was their victory over the human spirit. Hope for a world no longer imperiled has been extinguished in the hearts of the people of the Earth. Nuclearism, or rather those who ascribe to nuclearism, oppresses and imprisons us all. Their state-sponsored nuclear terrorism holds sway over all human affairs. The governed have been rendered powerless to evoke change in the established order. Enchained by nuclear ideology and the fear that it instills, the collective will to dismantle the machinery of death has been extinguished. Inertia will continue to impale us until we recognize that the arsenal of Armageddon and those who preserve it are the very incarnation of the horror they were designed to avert.

The continued presence of nuclear weapons on the landscape is not an historical inevitability. Their existence is arbitrary. They are perpetuated by the ruling elite of the countries that possess them. Refusing to acknowledge this, we remain powerless, victims to the nuclear agenda of these few. When we finally acknowledge that a closed circle of men and women willfully maintain the horror of potential nuclear genocide and destruction of the Earth, the rest of us, who abhor this depravity, will have diagnosed the malignancy that must be eradicated if the planet is to avert disaster.

Given a choice, most people will refuse to actively participate in the nuclear/radiological genocidal system. Their ethics and morality hold them back from supporting such horror with their deeds. Nevertheless, there are those among us whose consciences have been so corrupted and silenced that nothing remains within their hearts to repel them from faithfully serving the malevolent instruments of death. It behooves us to ask: Who are these people? What kind of mentality do they harbor that allows them to dwell amongst us while silently contemplating or actually preparing the annihilation of billions of others? What sickness lurks within their hearts? How can they willingly participate in the preparation for holocaust while rationalizing that their deeds represent a viable solution to the world's ills?

At our moment in history, it is prudent for the governed to focus their gaze on the pattern of mind that sustains the Cult of Nuclearists. It is their cast of mind that created the nuclear threat and which now perpetuates it. This cast of mind is a legitimate topic for serious psychological and sociological analysis. The survival of our entire species may depend on our ability to penetrate the shared psychology of the members that comprise this subculture.

The shared psychology of participants in a genocidal caste has already been

researched and comprehensively set down in print by Robert Jay Lifton and Eric Markusen in their 1990 groundbreaking book *The Genocidal Mentality: Nazi Holocaust and Nuclear Threat*. The authors conducted extensive interviews with scientists who had been involved in weapons development, nuclear strategists and retired military officers. Compiling their data and analyzing it from the perspective of social psychology, Lifton and Markusen began to discern psychological characteristics common among those in the nuclear establishment who helped create nuclear weapons, and those who devoted their lives to devising warfighting scenarios and perpetuating the threat of these weapons. These psychological characteristics united to form a shared "cast of mind." Drawing upon research they had previously undertaken, the authors observed numerous psychological parallels and patterns of behavior between this group, who made preparations for possible genocide in the future, and the Nazi doctors of the Third Reich who, during World War II, actually participated in the genocidal program to exterminate the Jews of Europe. In validation of their methodology, the authors pointed out that *"such comparison can enable the observer 'to discern a common causal mechanism otherwise unrevealed — to diagnose, in a sense, a human illness.'"* By comparing the two groups, Lifton and Markusen identified the "genocidal mentality," the common psychological dynamics and the resulting behavioral traits, necessary for a group to engage in, or have the intent to engage in, the annihilation of whole populations of human beings. They characterized the genocidal mentality "as a mindset that includes individual and collective willingness to produce, deploy, and according to certain standards of necessity, use weapons known to destroy entire human populations — millions, or tens or hundreds of millions, of people."

Nuclear and radiological weapons are instruments of genocide. In 1946, the UN General Assembly defined genocide as "a denial of the right of existence of entire human groups." The 1948 Convention on the Prevention and Punishment of the Crime of Genocide defined genocide as acts committed with intent to destroy, in whole or in part, a national, ethnic, racial or religious group. To meet current realities of radiological warfare, the concept of genocide must now grow to encompass the alteration of the gene pool of a group by radiologically induced mutations.

Acts of genocide are perpetrated by those whose thinking has drifted into profound dimensions of unreason and who have lost their ethical bearings. This is just as true for the human being who releases poison gas into a chamber of unsuspecting Jewish people as it is for the one who drops uranium weapons on unsuspecting Afghanis. What dominates the minds of such victimizers is a *disturbed pattern of thinking*. This pattern legitimizes their crimes in their own eyes and provides ongoing justification for repetition of their crimes over and over again. The source of this disturbed pattern of thinking is not mental illness. It arises from successful indoctrination in a *compelling* ideology. Realization of this funda-

mental fact is the critical key that unlocks the mystery of the mentality of genocide. **Genocide is a product of ideology**. It takes root and is sustained by people in power, people in government and in the military. In our era of inflated bureaucracy, what is particularly disturbing is that the "genocidal mentality can become bound up with the institutional arrangements necessary for the genocidal act." Large numbers of people, not fully cognizant (or in denial) of how their jobs contribute to the overall genocidal intention of their government, can become instruments for the carrying out of acts of genocide while mundanely going about their daily routines in the workplace.

The minds of people who contribute to acts of genocide require conditioning to prevent them from being repelled by their duties. For sane, well-educated professionals to collaborate in State sanctioned atrocities, they are compelled to adopt certain protective psychological mechanisms that protect them from experiencing the harmful effects their actions have on others. As Lifton and Markusen describe, the process of acquiring these defense mechanisms goes through an identifiable sequence of steps. Initially, to retain some semblance of normality in their personal lives while perpetrating horrific deeds, the well-trained victimizer is progressively conditioned to adopt the psychic strategy of "dissociation" or "splitting." Dissociation is "the separation of a portion of the mind from the whole, so that each portion may act in some degree separately from the other." In the process of habituating itself to abhorrent circumstances, the integrated, whole self seeks refuge by undergoing fragmentation into compartmentalized divisions. The human being grows increasingly accustomed to hosting within himself radically different vectors of thought and emotion that he can effortlessly switch between at will or by the dictate of circumstances. This allows the person to carry on the different roles in his life with a minimum of psychic conflict or apparent contradiction. Thus, for instance, a man employed as a nuclear strategist can share dinner with his wife and children, swapping laughs and stories of the day's adventures, and then quietly retire to his den to contemplate the kill ratio between megaton yields of various thermonuclear devices and population densities of potential targets of the enemy. This capacity of the human being to dissociate a part of the self from the whole is the breeding ground for what Hannah Arendt, in her book *Eichman in Jerusalem,* termed "the banality of evil." Dissociation allows evil thoughts and evil deeds to take root within the context of a seemingly normal life so as to become commonplace and humdrum without triggering any self-reflection or moral qualms of the iniquity in which one is participating.

To ensure that no human feeling or compassion disquiets the fractionalized mind that disinterestedly participates in the mass murder of defenseless women and children, the additional mechanism of "psychic numbing" gains sway over the dissociated self. Thought becomes separate from feeling. The capacity to feel becomes blunted. The ability to

empathize with the suffering of others increasingly diminishes. Such numbness allows victimizers, who are not outright sadists, to routinely perpetrate heinous deeds of murder and mayhem against the unsuspecting and the innocent. Although the comparison repels the mind, it must be made: There is a certain shared psychology between the Nazi doctor on ramp duty, who received his dehumanized victims as they disembarked from the boxcars and proceeded to sort them between the work camp and the gas chamber, and the operations analyst of the United States planning a military campaign that includes the dropping of uranium weapons on enemy populations. Both, immersed in the terrible duties they have been enlisted to perform, remain cold-heartedly detached from the suffering their actions will inflict in order to maintain their own psychological equipoise.

Depending on circumstances, dissociation and psychic numbing can drive a wedge even more deeply into the personality until "doubling" occurs. By this mechanism, the person develops within himself two separate operating systems that share in directing his behavior. With doubling, a second self is born within the being of the victimizer, and this second self is empowered to take control of his organism to perform whatever bestial behavior his duties may require. Thus, some Nazi doctors explained after the war that while carrying out their professional responsibilities within the concentration camp of Auschwitz, they developed an "Auschwitz self" that was separate and foreign to the self that lived outside the camp. Within the camp, the Nazi doctor dwelled in a hellish landscape of unceasing human anguish. He daily witnessed monstrous inhumanity and was personally responsible for perpetrating unspeakable horrors. His position within the camp placed him in contradictions that were numbing. He was a trained professional, a doctor, a healer. But on duty in the camp he served as a common thug and murderer. With the power of life or death over his captives, he had feelings of omnipotence. Simultaneously, he felt reduced to nothing more than a cog in a genocidal machine, powerless and impotent. While engaged in acts of extreme brutalization, he was accorded accolades as an instrument of the Final Solution and a healer of the Aryan race. Extreme psychic numbing was a constant requirement. He extinguished all human feeling within himself for the suffering victims that flooded his sight with every turn of his head. The Auschwitz self of the Nazi doctor made a home for itself amidst the atrocities of the concentration camp. The ghastly deeds it participated in was nothing more than the normal, mundane routine demanded of his job. Through no great effort of will, this brutal Auschwitz self dropped away from the doctor of death as he passed out through the gate and returned to his domestic life with wife and children and relaxed in the refined cultural pastimes enjoyed by middle class Germans.

Although distasteful and difficult to acknowledge, no difference exists in the current context of our civilized nuclear barbarity. Lifton and Markusen quote Archbishop Raymond G. Hunthausen as saying: "I say with a deep consciousness of these words that

Trident [submarine] is the Auschwitz of Puget Sound." A nuclear submarine is a manifestation of the intention to commit genocide. It is an Auschwitz in waiting. The sailors submerged beneath the waves on a submarine armed with nuclear weapons carry out their routine preparations for instantaneous genocide of unsuspecting human beings elsewhere on the planet while in the sway of their own Auschwitz selves which disappear when shore leave returns them to their other lives and other selves. On this side of genocide, these men are not criminals. They are patriots motivated by the intention of performing service to their country. Nevertheless, they are willing servants of the genocidal mentality. If ever called upon by leadership to break the waves with their missiles, these sailors will be instantaneously transformed into the most heinous war criminals ever to exist.

As dissociation, psychic numbing and doubling become entrenched in the mentality of a recruit in a genocidal machine, he reaches a stage of conditioning that permits him, with little psychological cost to himself, to participate in ongoing acts of "brutalization" of others. As part of a bureaucratic system that approves of his atrocities and rewards him for them, he becomes increasingly detached from his deeds and feels less and less responsibility for them. In this state, the harm he is capable of inflicting can escalate dramatically. A doctor recruited to the Nazi cause was systematically indoctrinated to perform murder on behalf of the state. The ideology proclaiming the superiority of the Aryan race and the need for racial cleansing promoted the idea that some lives were unworthy of life and killing was a redemptive deed for healing the sickness of the nation. Repeated exposure to prevalent ideas such as these cultivated within a doctor a willingness to participate in the mercy killing of the physically and mentally handicapped. Once inculcated to perform this entry-level position of executioner, the Nazi doctor's capacity for brutality could be more easily manipulated. He was then promoted to carry out an expanded euthanasia program that targeted healthy people who were deemed undesirable elements of the state. Once habituated to this enhanced dimension of brutalization, a "doctor" was prepared and ready to perform even greater service to his country by working in the death camps to eradicate the Jewish people.

Disturbingly, the world today is being prepared for an escalation in brutalization by the Cult of Nuclearists via the deployment of radiological weapons. Uranium ammunition used during the First Gulf War was confined primarily to relatively small, non-explosive projectiles on the battlefield in attacks against enemy armored vehicles. A more brutal dispersal of radioactivity occurred in Afghanistan with the dropping of a large number of heavy bunker-buster bombs. Many of these bombs, each containing hundreds or thousands of pounds of uranium, were detonated near population centers, exposing a much larger number of people to internal contamination. In the Second Iraq War of 2003, independent observers measured heightened levels of radioactivity in downtown Baghdad,

bearing witness to the detonation of uranium weapons in heavily populated centers. The contemplated escalation to the deployment of mini-nukes to destroy hardened targets will represent a further expansion of brutalization. Greater numbers of people will be hurt by the blasts and contaminated with a greater array of radioactive elements that will induce a broader range of acute and chronic ailments.

The whole purpose of this chapter is to underscore the fact that the Cult of Nuclearists is comprised of people whose minds have been perverted by dissociation, psychic numbing, and doubling to the point where they have been rendered capable of carrying out horrific deeds of brutalization. These fractured human beings, consumed with a mental sickness, hold in their hands the destiny of our species and the continued viability of planet Earth. It is the utmost in folly for humanity to continue to accede to their leadership. They are not representatives of healthy human living. Their mentality compromises their ability to be guardians of Life. Their sickness can only beget more sickness. How can they be entrusted with weapons of mass destruction? This is a grave dilemma that cannot be frivolously dismissed. By not standing up and actively opposing their twisted thinking as it applies to the broadcasting of radioactivity throughout the biosphere, we become complicit in their deeds. As such, we may very well end up victimizing ourselves with extreme brutality.

To comprehend how genocide becomes institutionalized as national policy, something more is required than a simple understanding of the psychological mechanisms individuals incorporate within themselves to adjust to grisly deeds of mass extermination. According to Lifton and Markusen, the actual genocide of the Nazis and the intention to carry out genocide if circumstances so warrant it, formulated by American war planners after the creation of the hydrogen bomb, evolved from "common causal mechanisms." An elucidation of these mechanisms can make the outbreak of genocide comprehensible.

Genocide as national policy always arises in response to historical circumstances. It never appears all at once, fully formed, out of nowhere. It takes root and develops over time within a group that has shared a collective trauma. And within its context, the systematic extermination of another group of people appears as a "reasonable" solution to either a real or perceived vulnerability. As Lifton and Markusen emphasize, there is always a logic to social madness. In fact, the harboring of a perverse logic amongst members of a group is what legitimizes, in their own eyes, the totally insane enterprise of genocide. This shared perverse logic is one of the distinguishing characteristics of the genocidal mentality.

A group that has endured a collective trauma is receptive to the rise of a rehabilitating ideology, which in its most extreme form can plant ideas that will eventually culminate

in a campaign of genocide. **Ideology always drives the inauguration of genocide**. Formulated by either a single human being or a small contingent of like-minded individuals, this ideology is precipitated by "*the psychological characteristics of a particular group of people centrally involved with significant historical forces of their era*." This core group of individuals with their shared psychology promulgates the ideology in expanding circles of influence until it is eventually embraced by the leadership of the nation, the military and the monied interests that support and follow the agenda of the ruling power structure. To fire the hearts and minds of its intended audience, the emerging ideology needs to be charismatic, and simultaneously dogmatic, in its articulation of the current historical forces acting on the society and the collective ills that these have created. To be captivating, the ideology must outline a path, that when followed, will provide a cure for the society's ills. More specifically, the ideology that prepares the groundwork for genocide elucidates within a consistently logical framework the collective trauma inflicted on the people that led to their current state of vulnerability, outlines a path of action by which the people can regain their security, and offers each member of the society a cure for their personal suffering if they embrace the new ideology and actively incorporate it into their lives. To carry the necessary force to sway people's lives, the propounded ideology must be totalistic in its explanations and intolerant of competing or alternative points of view. So complete is the worldview offered up by the ideology that it takes on a mystical or spiritual force. It becomes like a religion offering to its followers transcendence and salvation.

During the birth and infancy of an ideology capable of evolving into genocide, the genocidal implications are not immediately apparent. They remain unvoiced, silently crouched within the socially shared rhetoric. What is broadcast explicitly are ethical claims that offer a moral justification for undertaking the extreme solutions that are being implied. This ethical framework serves to legitimize the ideology, assisting to disguise or make antiseptic the underlying savagery that is being hinted at. To win adherents, the ideology propounds a polarized view of the world in which one's own group is characterized by all that is Good, and as a consequence, the opposing group(s) is smeared as the epitome of Evil. It is then a short step to the inevitable conclusion that the only way to deal with the evil is to eradicate it. Murder becomes the necessary, reasonable and acceptable response to the threat posed by the evil others. By this means, the victimizers come to view themselves as virtuous. They are the heroes of the state. And their tortured, brutalized victims are the villains that deserve their death sentence. To further legitimize their crimes, those instigating genocide portray their crime as another victory in the grand military tradition of their country of fighting and winning wars. By this tactic, the governed actually garner pride in their nation's successful brutalization of another population.

Far from being an act of passion carried out in a moment of abandon, genocide is

a sustained, methodical enterprise applied in a coldly rational manner. Required for its successful application is a well-organized infrastructure and protracted logistical support. Once genocide is underway, an increasing number of people are recruited to support the effort in some capacity or to actually carry out the massive bloodletting. Increasingly, interlocking segments of the society are mobilized, and the genocidal enterprise gathers institutional and bureaucratic momentum. The mentality for genocide spreads throughout the population and becomes identified with service to the state and an expression of national loyalty. Bystanders, ordinary citizens not actually involved in the mechanics of the killing, begin to acquire sentiments similar to the leadership of the regime or to the actual perpetrators of the violence and raise no objection to the horror taking place behind the veil of their everyday lives. This is perhaps the most significant feature of state-sponsored genocide. **The entire population is complicit in the genocidal undertaking**. The citizenry, with varying levels of awareness, supports in one way or another the genocidal machine. They give political support and loyalty to the figureheads of the ruling ideology. They finance the work of genocide through taxation. They offer no vocal opposition and thus grant implicit consent to the killing. In the course of doing business or performing their daily labor, ordinary citizens reap financial benefit for themselves by producing the arms and matériel required by the actual executioners to carry out the genocidal venture. This point cannot be overstressed. There is always an element of profit-making that accompanies the genocidal undertaking of a society. Exterminating others is good for business, promotes productivity, and increases wealth and prosperity. This is true regardless of whether profiteering is done with full awareness of the consequences of one's deeds or done under the protective covering of dissociation, psychic numbing and doubling. If they participate in no other way, the citizens unwittingly support the genocide taking place all around them by withdrawing from the killing fields into the cocoon of their private lives, turning off their feelings of compassion for the victims, and remaining silent.

What is forever confounding, even when apprehended intellectually, is the fact that the perpetrators of genocide and their silent supporters are not psychopathic monsters. Caught in a genocidal machine, they are just regular people, going about their lives, doing the job at hand, in order to get by. *This is as close as one can get to catching an unobstructed glimpse of the illness which is the genocidal mentality. It slowly infects the thinking of a people in so insidious a way as to not even be noticed by them*. When one understands this critical point, the Holocaust no longer remains so inexplicably incomprehensible. Similarly, awakened by this insight, we may catch a fleeting and painful glance of ourselves as silent coconspirators in today's incarnation of the genocidal mentality. Lulled to sleep by the wealth and abundance of North America, we live in denial of the fact that our way of life is sustained by threats of genocide to competing populations. By offering allegiance to the established policies of our government, we simultaneously offer allegiance to the nuclear genocidal machine that is

primed and ready to engulf the world in flames and enduring contamination. Our life, liberty and pursuit of happiness has been corrupted by this silent, tyrannical ideology that may one day erupt in the merciless devastation of all we hold dear in life and all that is good. Our tacit support of this reality is today's embodiment of the banality of evil.

The Holocaust perpetrated by the Nazis is history. But the resolution to beget unimaginable atrocities is very much alive, sustained by an up-to-date incarnation of the mentality of genocide. The visible manifestation of this intention are the nuclear arsenals scattered throughout the world silently poised, waiting to be triggered. Whereas the Nazis actually mobilized a genocidal machine that consumed tens of millions of lives, the Cult of Nuclearists has erected an analogous machine based on the *intention* to commit genocide at some unspecified moment in the future. Aside from this fundamental difference, the pattern of forces that led to Nazi savagery is a mirror for the circumstances that gave rise to the nuclear menace of today.

The Cult of Nuclearists and its program for planetary ravagement arose in response to unique historical circumstances and profound cultural traumas that shook the American psyche at the close of World War II and the years soon after. The successful development of the atomic bomb provided the United States with a weapon of ultimate terror. It was dropped on Hiroshima and Nagasaki to terrorize the Japanese into surrender. It was dropped also in the hope of terrorizing the Soviet Union into postwar constraint, putting them on notice that the United States was the dominant power to emerge from the conflict. What was not anticipated was that the atomic bomb would end up terrorizing the American population as well. Although the world welcomed the bringing of peace after years of global conflict, the detonation of the bomb was a deeply unsettling psychological event. As related by Lifton and Markusen: "Anne O'Hare McCormick declared in the *New York Times* that the atomic bomb had caused 'an explosion in men's minds as shattering as the obliteration of Hiroshima.'" The immensity of the destructive power of the bomb disturbed many people's basic sense of security. People could envision a future, not to distant, where safety from harm would no longer be an assured element of life. Lurking just beyond the fringes of consciousness, the new American experience was one of an unnerving vulnerability. This subliminal terror became manifest and was compounded exponentially when the Russians detonated their own atomic weapon in 1949. The brief monopoly that the United States enjoyed in being the unrivaled international superpower was instantly dashed. The realization began creeping into Americans' lives that they could realistically be the victims of Russian atomic bombs raining down upon their own cities. The tension increased with the onset of the Korean War and the escalating confrontation between countries with Communist ideologies and the West. The cultural trauma peaked with the detonation of the hydrogen bomb in 1953. Although the atomic bomb represented an

unprecedented means of destruction, it nevertheless was limited in scope. The hydrogen bomb, however, was an instrument of unlimited devastation. Theoretically, it could be designed to create any level of destruction imaginable. It had the power to erase from existence any enemy it was directed against. By its very nature, it was a weapon of genocide. Being in possession of such a weapon fundamentally transformed the thinking of those who possessed it. Absolute power corrupts absolutely. The hydrogen bomb marked the birth of the modern mentality of genocide.

America's method of waging war had been inching toward mass extermination prior to the advent of nuclear weapons. When America entered the European theater during the Second World War, it relied heavily on aerial bombing as part of its joint offensive strategy with its Allies. Clinging to some concept of humanitarian principles, it advocated a policy of precision bombing whereby military and industrial facilities invaluable to the enemy were targeted and the random bombing of civilian centers was resisted. As the war continued, attempts at precision bombing by day gave way to radar-guided night bombing which, to be effective, necessitated "area" or "carpet" bombing. Cities and civilians became acceptable targets as bombing was used to weaken the morale of the general population. A "science of city-burning" evolved. Incendiary attacks were made upon every significant population center in Germany. Four massive assaults on Hamburg in the late summer of 1943 ended in a tremendous firestorm that incinerated 40,000 Germans. The Allied attack on Dresden on February 13, 1945 ignited a firestorm that engulfed the city and took the lives of between 40,000 and 250,000 people. A similar raid on Tokyo in March 1945 killed 130,000 people. Within this context, the atomic bomb was nothing more than a more efficient vehicle for bringing about similar ends.

The development of the hydrogen bomb rendered this approach to warfare completely obsolete. The unlimited capacity for destruction and radioactive ruination antiquated all previous thinking on the meaning of national security and the successful application of military force. With the Soviet Union in possession of the hydrogen bomb, the United States, for the first time in its history, was assailable and open to destruction. Terror was no longer some abstract notion. It was a visceral experience for many an average citizen.

It was within this historical context of terror and vulnerability that the modern genocidal mentality was born. Grappling with the terrible realities into which the world had plunged, politicians and military strategists sought renewed security and invincibility. Analyzing the options of confronting an enemy with parity in unlimited destructive capability, America's inner circle of warrior-statesmen forged a new redemptive ideology: deterrence. The meaning of the verb "deter" is "to frighten from" or "to restrain by fear." Deterrence ideology preached that security from nuclear threat was achievable by amassing

an arsenal so formidable that an enemy seeking to cross swords with the United States would be restrained by the assurance of massive retaliation, i.e., genocide. The way to forestall terror was to terrorize. The way to avert annihilation was to make ready to annihilate any opponent. Lifton and Markusen state the following:

> Unlike overt Nazi victimization of Jews and others, the claim of nuclearism is always prevention, the weapons to be used only "if deterrence fails." this contingent aspect of genocidal intent enables us to resist recognizing it as genocidal intent. It would be hard for us to make that recognition and continue to see ourselves as an open democratic society proud of its moral claims.
>
> As in the case of the Nazis, the nuclearists cannot publicly acknowledge —or, at least, not quite — the degree of brutalization — of genocidal intent, contingent or otherwise. There is for the nuclearists, as there was for the Nazis, a dark "secret," only partially and ambivalently kept, but crucial to the endeavor.

The cornerstone of deterrence ideology is straightforward. For deterrence to be credible to all adversaries under all circumstances, the leadership of the nation must carry within themselves the resolve to initiate a holocaust "if deterrence fails." Thus, those acceding to positions of power and authority within the government and the military must harbor a genocidal mentality. Their character must be one of either outright ruthlessness or banal normality carefully pieced together by dissociation, psychic numbing and doubling. Only such individuals can muster the necessary brutality, should it be required, to fulfill the ultimate mandate of deterrence ideology: unprecedented carnage and butchery. Heinrich Himmler, addressing in 1943 elite SS regiments responsible for carrying out the Holocaust, made a statement that is equally applicable to those who today serve the nuclear genocidal machine:

> Most of you must know what it means to see a hundred corpses lie side by side, or five hundred, or a thousand. To have stuck this out and — excepting in cases of human weakness — to have kept our integrity, this is what has made us hard. In our history, this is an unwritten and never-to-be-written page of glory.

The evolution of deterrence ideology was formulated by a small cadre of politicians, military personnel and defense analysts, referred to throughout this work as the Cult of Nuclearists. It was their mentality and worldview that fueled the arms race and created the nuclear threat that exists today. While wishing to retain nuclear weapons as the cornerstone

of the military might of the United States, they conceived of no other way of parrying the hazard posed by another nation possessing similar weapons than to build an arsenal of Armageddon that would threaten such violence that it would deter any aggressor. The genocidal ideology of deterrence formulated by the Cult of Nuclearists, like the genocidal ideology of the Nazis, was dogmatic and intolerant of other points of view. Never seriously allowed into the discussion of how to deal with nuclear weapons were other competing visions for the world. To offer just one example, the Nobel prize winning physicist Niels Bohr proposed a set of ideas that could have provided the foundation for a competing ideology if it had ever been embraced by a community of people in power and authority that differed in their mentality from those who created the Cult of Nuclearists. Bohr realized that the atomic bomb mandated a reworking of international relations. To avoid a nuclear nightmare, like the one we have today, Bohr envisioned the development of an open world modeled on the free interchange of science and scientists that existed prior to the Second World War. As Bohr wrote in an open letter to the United Nations in 1950:

> Within any community it is only possible for the citizens to strive together for common welfare on the basis of public knowledge of the general conditions of the country. Likewise, real cooperation between nations on problems of common concern presupposes free access to all information of importance for their relations. Any argument for upholding barriers of information and intercourse, based on concern for national ideals or interests, must be weighed against the beneficial effects of common enlightenment and the relieved tension resulting from such openness (Rhodes).

In another letter written previously, Bohr wrote of the relative harmony that had evolved between the nations of Scandinavia who had once faced off against each other and the rest of Europe with the same hostility that later developed between the United States and the Soviet Union. To achieve such concord in the post-Hiroshima world, Bohr envisioned a consortium of nations living in harmony. The basis for this new coalition of nations was openness.

> An open world where each nation can assert itself solely by the extent to which it can contribute to the common culture and is able to help others with experience and resources must be the goal to put above everything else. The very fact that knowledge is itself the basis for civilization points directly to openness as the way to overcome the present crisis (Rhodes).

Bohr resisted the notion of a world government based on centralized authority of all

affairs of the Earth. This was an idea that was much touted at the time. Many foresaw that the only way to avoid nuclear confrontation between nations was the elimination of nationalism and unification of all the nations of the Earth under one government. This had entirely different connotations during the era immediately after World War II than the modern idea of a New World Order. The New World Order which is evolving today may very well evolve into a one-world government based on elitism and a world controlled by centralized finance, globalization of markets, centralized control by international corporations of the world's wealth, resources, food supply and so forth. It is not beyond the realm of possibility that the people of the Earth will be herded by the threat of nuclear destruction into accepting this radical and perhaps enslaving social arrangement. The Cult of Nuclearists controls weapons of doom and trepidation. By unleashing these weapons in scenarios of limited nuclear war or terrorism, the hearts of humanity will be overwhelmed by such fear and dread that they will unhesitatingly relinquish their freedoms and bow down to any tyranny that promises salvation. Such a devilish scenario may have been in the mind of Henry Kissinger when he authored these words:

> Today Americans would be outraged if UN troops entered Los Angeles to restore order; tomorrow they will be grateful! This is especially true if they were told there was an outside threat from beyond, whether real or promulgated, that threatened our very existence. It is then that all peoples of the world will pledge with world leaders to deliver them from this evil. The one thing every man fears is the unknown. When presented with this scenarios, individual rights will be willingly relinquished for the guarantee of their well-being granted to them by their world government (Kissinger).

There is an element of insanity at the heart of deterrence ideology. The perceived vulnerability of leaders of the United States of being in the sights of another nation's nuclear weapons calls forth the response of maintaining an arsenal of overkill on hair-trigger standby. Other nations, perceiving a threat posed by our defensive measures, are forced to reciprocate in kind. The shared mentality that gives refuge to such thinking inexorably vaults the entire world to a precipice where the security of nations and the welfare of billions of human beings teeters precariously. By the logic of deterrence ideology, this is a "reasonable" state of affairs for the preservation of peace in the nuclear age. The way to create harmony between peoples is to threaten those who are "other" with merciless acts of genocide. That security and peace has so far reigned under this state of affairs is the kernel of logic that knits together the social madness of today's nuclear terrorism practiced between nations. One cannot help but wonder if this really is the best solution that the human race is capable of achieving as a response to the scientific discoveries of controlled nuclear fission and nuclear fusion. Perhaps it isn't. Maybe it is nothing more than an arbi-

trary ideology imposed upon the entire world by a small clique of ruling elite who happened to be in power during the second half of the twentieth century. From this point of view, deterrence ideology is nothing more than an expression of the "psychological characteristics of a particular group of people centrally involved with significant historical forces of their era."

Meeting the criteria of an ideology predisposed to genocide, the worldview promulgated by deterrence is fanatical and totalistic. We and our allies are Good. Other nations in possession of nuclear weapons which differ from us in terms of their values, their forms of government, the use to which they put their mineral reserves, their markets, perhaps even their skin color and religion and so forth, are Evil. We are the people of truth and integrity; they are consummate liars. We are people of God; they are unscrupulous heathens and unbelievers. Our way of life is based on justice, theirs on injustice and tyranny. Given the opportunity, these evil ones will destroy us. Our only recourse is to make ready to destroy them. They are nefarious, always seeking an advantage over us. To counter their villainous schemes, we must incessantly devise superior weapon systems that will thwart every possible advance. They dedicate their wealth to our destruction. Our only alternative is to pour our wealth into more perfect methods of annihilating them. "If deterrence fails," we are ready to justly deal out to them genocide to free the Earth of their despotism. Our higher purpose for performing such deeds legitimizes a violation of our ethics. This is just a modern incarnation of the Nazi creed of killing to heal. An ethical justification is given to the intent to commit genocide in order to disguise its underlying barbarism.

As with Nazi ideology, deterrence ideology of the Cult of Nuclearists invests science with the role of magical redeemer from the vulnerability created by the nuclear weapons of the evil ones. The nuclearist supersedes religious belief with an unshakable conviction that science holds the key to worldly salvation. Via science, any threat will be countered and trumped. Science will deliver into our hands superior firepower. It will guide us to erect impregnable defenses. It will provide the means of eavesdropping on our enemies, pinpointing their weapon caches, conducting stealth warfare, insuring unimpeded communication in the chaos of battle. Super bombs, smart bombs, x-ray lasers, Star Wars, global positioning satellites, Trident submarines, B-2 bombers, on and on and on. Rather than seeking a rearrangement of international affairs by improving human relations, the Cult of Nuclearists leads the world by example in amassing infernal weaponry to be mercilessly unleashed when deemed justified by a handful of decision makers.

All those involved in the scientific enterprise of making ready for genocide in defense of the state derive personal satisfaction and meaning in their lives by their participation. This is as true for the theoretical physicist pursuing breakthroughs that will advance weapon

technology as it is for the defense contractors and their employees that will fabricate new instruments of warfare and those enlisted in the armed forces that will operate them. Cushioned from fully acknowledging the ultimate intentions of their work by such psychological maneuvers as dissociation and psychic numbing, these people derive empowerment by partaking in the science and technology that will insure the continuation of our way of life and preserve us from the aggression of our adversaries. Unmasking nature's secrets and transforming that knowledge into sophisticated technology is a heady experience. All who are touched by the noble grandeur of science, like the devotees of a religious tradition, undergo a personal transformation. Their lives comes to be identified with the science with which they commune, and they become, in some sense, exalted by their work. This capacity of science to deeply touch the lives of its votaries is a powerful element of the modern mentality of genocide. Armies of workers with faith in the promise that science will deliver humankind from ruin willingly engage in jobs that perpetuate the genocidal machine.

The lure of sophisticated technology permeates our entire culture. We are enchanted by our inventions, mesmerized by our technical achievements. The Cult of Nuclearists capitalizes on this proclivity in order to keep the instruments of catastrophic death within our midst. Images of weapons of destruction weave an hypnotic hold upon us. Thermonuclear detonations invoke a terrible awe. As images of precision bombings flash across our television screens, an excitement stirs the organism and an intellectual satisfaction permeates the mind. A nuclear missile breaking the waves upon liftoff from a submarine, then igniting and lifting skyward, can engender pride and amazement in the ingenuity of human beings. Dazzled by such pyrotechnics, it is easy to overlook that we are witnessing instruments intended for the extermination of unwitting masses of humanity. If we were truly mortified by these displays, we would work for their eradication. But we aren't, and we don't. Recognizing ourselves as indifferent spectators to these displays of the implements of carnage, we may espy our unconscious collusion in our nation's readiness for genocide. By playing on our fascination with their ingenious weaponry, the Cult of Nuclearists has seduced us and transformed us into their silent accomplices.

If ever the opportunity arose to explain to strangers from a distant land the ease with which human beings could obliterate themselves, they would assume that only thugs and butchers could man the nuclear genocidal machinery. They would listen incredulously as we struggled to correct their misconception by explaining, that no, it was our best and brightest that staffed our engines of harrowing affliction. Analogous to the Nazi cleverness of enlisting doctors to be among the most conspicuous facilitators of the Final Solution, the Cult of Nuclearists recruits well-educated professionals to maintain their infernal instruments, and when called upon, carry out their will. Given the technological sophistication of modern weaponry, only a cadre of intelligent and learned specialists is capable of ready-

ing and operating the missiles, airplanes, submarines; the guidance systems; the computer and communication systems that together will rain indiscriminate death on entire populations. The quality of manpower involved in the preparation for Armageddon overlays a veneer of legitimacy and respectability to the entire enterprise.

Successful recruitment of an elite corps, psychologically prepared to commit crimes against humanity on orders from their superiors, requires a sophisticated and malevolent process of socialization. The nation's population is mined for impressionable and malleable young adults whose personalities are receptive to wholeheartedly embracing a compelling ideological package of patriotism, nuclearism and deterrence ideology. Appeal is made to their patriotic and noble impulses in regards to serving their country, defending democracy, protecting the homeland, fighting for freedom and so forth. These ideals are nourished in the hearts and minds of willing recruits and then slowly married to the realities of modern warfare whereby service to the nation becomes inseparable from taking responsibility for maintaining, and if necessary, launching weapons of mass maiming, infanticide and genocide. Self-interest and social advancement are prime motivating forces driving people to volunteer for positions within this enterprise. Attractive bonuses are offered in exchange for service. A uniform, rank, prestige, money for a college education, technical training for a future occupation, graduated pay increases, an opportunity for travel, free healthcare, a pension, and the like are powerful motivators by which to enlist a pool of talent. As novitiates are shepherded through their basic training in whatever branch of military service they have enlisted, further socialization transpires that creates an obedient and unified fighting force. At completion of training in the traditional military arts, servicemen and women move on to areas of specialization. It is at this point where traditional soldiering is metamorphosed into serving the genocidal machine. Willing candidates sign up for training that prepares them to serve in some capacity in the fielding of weapons of mass destruction. During the course of their education, ongoing drilling and testing selects those individuals with the requisite mentality, those who will not flinch in carrying out their duties when ordered to do so. The Nuclear Weapon Personnel Reliability Program continuously evaluates performance so that "only those personnel who have demonstrated the highest degree of individual reliability for allegiance, trustworthiness, conduct, behavior, and responsibility shall be allowed to perform duties associated with nuclear weapons" (DOD). Those who meet these criteria are the prideful professionals who have risen to the top of their area of specialization. On behalf of the rest of us who they purportedly protect, these weaponeers are readied to bear the burden of pushing the button or dropping the bomb as part of our nation's unwritten and never-to-be written page of glory.

The nation's instruments for genocide did not emerge from a vacuum. To construct its genocidal machine, the government of the United States required the help of large

sectors of the nation's industrial infrastructure and its labor force. Profiteering was an inseparable element of the business of fabricating weapons of mass destruction. The wealth of the nation was funneled into the coffers of defense contractors and subcontractors As stated in *The Hidden Costs of Our Nuclear Arsenal*: "From 1940 through 1996, we spent nearly $5.5 trillion on nuclear weapons and weapons-related programs, in constant 1996 dollars" (Schwartz). Every nut and every bolt that went into nuclear weapons and their very sophisticated delivery vehicles created profits for businesses throughout the country. With this money trickling through the economy, the prosperity of the nation as a whole was enhanced. The production of nuclear weapons also facilitated an attractive redistribution of wealth to many areas of the country. As noted in *The Economic Implications of Nuclear Weapons*: "After World War II, Department of Defense programs, and, specifically, nuclear programs, became the vehicle of choice for delivering pork-barrel funds to various regions" (Weida). On the downside of nuclear weapon production, the nation as a whole suffered deprivations by having its wealth diverted from programs that could have more directly enhanced the lives of its citizens.

> Nuclear weapons spending over this 56-year period exceeded the combined total federal spending for education; training, employment, and social services; agriculture; natural resources and the environment; general science, space, and technology; community and regional development (including disaster relief); law enforcement; and energy production and regulation. On average, the United States has spent $98 billion a year on nuclear weapons (Schwartz).

All citizens of this country have been touched by our government's commitment to nuclear weapons. Everyone has played some part in this enterprise. Admittedly, the thought is distressing, but Americans need to face their complicity in their government's preparations to unleash mass extermination. As in Nazi Germany, the machinery of genocide would have been impossible to create and sustain without the tacit approval of the population. The instruments to inaugurate catastrophic death, accompanied by the infrastructure and personnel necessary to support them, are scattered throughout our nation, and yet, we blithely carry out our lives as if they don't exist. A portion of our taxes are earmarked to maintain this arsenal. We repeatedly elect leaders who serve the Cult of Nuclearism. With unwavering patriotism, we send our children into military service where they are used as instruments for scattering radioactivity across other people's homeland. Many of us derive our livelihood by contributing knowingly or unknowingly, directly or indirectly, to the construction, maintenance or deployment of some component of the implements that one day will rain carnage. We voice no objection to this state of affairs. We take pride and delight in our security, prosperity and democracy, but we refuse to acknowledge that these are granted to us by the threat of genocide our government projects over all the world. If

ever nuclear catastrophe breaks out in any form, we have forfeited the right to call ourselves innocent bystanders. We have allowed the stage to be set for nuclear calamity. We perpetuate this vulnerability by making no effort to remove it from our midst. Ultimately, we have paved the way for our own victimization of ourselves.

The will to commit genocide and the means to achieve it have become routine and institutionalized. Lifton and Markusen observe this: "It is not that American leaders are necessarily more callous or immoral than leaders of other states. Rather, the existence of a genocidal system, made possible by mere technological capacity and commitment to the weapons, helps sustain the genocidal mentality." What is particularly worrisome is that once activated, the nuclear genocidal machine may have a built-in momentum that will make it unstoppable. Just as the killing and the preparation for more killing in Nazi Germany propelled the genocidal endeavor forward until it acquired a seeming life of its own, the fail-safe mechanisms designed into our own arsenal may make the outbreak of nuclear war, under unpredictable and tense circumstances, uncontrollable. With the engines of ruin cocked and readied, we may slip into the abyss so quickly that most of us won't know what happened. This unholy state of affairs is the legacy of the mentality of genocide. It will continue to cast its pall over all the Earth until a new mentality sweeps it away.

There was a moment when many people throughout the world caught a glimpse of an alternative reality to the one of instantaneous holocaust envisioned by deterrence ideology. When the Soviet Union collapsed in 1989, there was a lessening of international tensions. The apparent threat of an opposing superpower vanished from our radar, and we were left without an adversary to justify the nuclear behemoth. If a different mentality had been at the helm of the nation and our fate, statesmen could have seized the moment to loosen the noose of nuclear terror and set the world on a different course.

At that moment, the Cult of Nuclearists overplayed its hand and unmasked its unstoppable lust for employing the energy of the atomic nucleus to conquer. In 1991, US forces in Iraq unveiled usable radiological weapons in the form of depleted uranium munitions. The war in Afghanistan in 2001 and the second war in Iraq in 2003 bore witness to an expanding variety of weapon systems incorporating radioactive material and the increasing reliance on these armaments by the US military to achieve dominance. In concert with this new weaponry, a new, all-consuming ideology emerged from the rubble of the World Trade Center on September 11, 2001: the War on Terrorism. According to the worldview propounded by this ideological shift, America was under attack by terrorists intent on destroying our way of life. To counter this threat, the United States had no choice but to take up arms against terrorists nested throughout the world.

The ideology of the War on Terrorism is a metastasis of deterrence ideology. It was formed in the same mold and is a product of the same mentality. It arose in response to the shared collective trauma of 9/11 and spoke to people's fears in the wake of that tragedy. Promulgated by a small group of key players within the Bush administration, the ideology of terrorist threat was instantly adopted by all major channels of the media and broadcast into the hearts of the citizens of the nation. A new worldview rapidly crystalized where Americans were suddenly vulnerable to unexpected, violent attacks at any moment by shadowy people, concealed within Muslim countries, who hate us. Yet again, we good people who adhere to democracy and freedom are polarized against "them" who are evil and unprincipled. Latent in the polarization is the righteousness of Judeo-Christian ethics and traditions in irreconcilable conflict with an Islam that must represent godlessness because it nurtures militant fundamentalism and the oppression of women. The reasonable response to the ever-present threat of terrorism is to be preemptive, declare war on terrorism and carry the battle to the enemy. The ideology of terrorist threat justifies the invasion of any nation deemed to be harboring terrorists. Not surprisingly, to date, those nations harboring terrorists have also been nation's harboring oil or whose geographical position represents an obstruction to the acquisition of oil elsewhere.

Like Nazism and deterrence ideology, the War on Terrorism has buried within it genocidal implications which are not immediately apparent. It is an incontestable fact: terrorists exist in the world. They represent a threat to the security of the United States, and that threat needs to be countered. But it is equally incontestable that you don't wage war against terrorists with weapons of indiscriminate effect. Doing so is unconscionable. Terrorists cloak themselves in anonymity and derive protection by embedding themselves within civilian populations. Dropping radiological weapons on those populations to defeat terrorism is senseless and criminal. The radioactivity is not absorbed selectively by people harboring terrorist sympathies while leaving the rest of the population unscathed. No, whole populations are intentionally targeted with agents capable of inducing chronic ill health and life-threatening pathologies. The ruthless contamination of whole populations, carried on with seeming indifference to the suffering this causes and the ruination of people's lives, is a visible expression that the mentality of genocide is very much alive in those politicians and generals who propel the American war machine. It is beyond credibility that all those in positions of authority within the US military are unaware of the radiological effects uranium weapons have on the health of targeted populations. If they truly dwell in such ignorance, they should be relieved of their duties, for they are acting irresponsibly and committing blatant crimes against humanity. A more believable scenario is that they are cognizant of the radiological impact of their weapons, but they simply don't care. Their mentality prevents them from acknowledging that what they do is criminal.

Thermonuclear and radiological weapons and the ideologies that rationalize their

deployment are ultimately corrupting of the lives that become intertwined with them. These evils demand servants who, if called upon, will unswervingly harken to the monstrous duty of exterminating millions. The savagery of these weapons demands this degree of servitude and devotion. The continued presence of nuclear/radiological weapons in human affairs is self-selecting of the type of person who is willing to wield them. Those individuals who have no qualms of having their very selves transformed into vessels for preserving the mentality of genocide conclude, so to speak, a bargain with the Devil. Only they are the ones who are rewarded with becoming presidents, cabinet members, congressmen, and generals with the power, prestige and wealth that accompany these stations. This is an unabashed glimpse of what constitutes leadership and power in a nuclear state. And the governed meekly acquiesce to this state of affairs whereby those with the genocidal mentality are the very ones entrusted with the responsibility for preserving us all from decimation.

There is nowhere else to end than where we began:

> *"At Nuremberg after the Second World War, there was an attempt to hold individuals and groups accountable for their role in killing. There can be no nuclear Nuremberg; hope lies only in establishing responsibility for genocide prior to its occurring — responsibility for participating in a genocidal system and a genocidal process."*

18

Depleted Uranium Weapons and Humanitarian Law

Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I), 8 June 1977.

Article 48. Basic rule:

> *In order to ensure respect for and protection of the civilian population and civilian objects, the Parties to the conflict shall at all times distinguish between the civilian population and combatants and between civilian objects and military objectives and accordingly shall direct their operations only against military objectives.*

Article 35. Basic rules:

> *1. In any armed conflict, the right of the Parties to the conflict to choose methods or means of warfare is not unlimited.*
>
> *2. It is prohibited to employ weapons, projectiles and material and methods of warfare of a nature to cause superfluous injury or unnecessary suffering.*
>
> *3. It is prohibited to employ methods or means of warfare which are intended, or may be expected, to cause widespread, long-term and severe damage to the natural environment.*

Article 55. Protection of the natural environment

> *1. Care shall be taken in warfare to protect the natural environment against widespread, long-term and severe damage. This protection includes a prohibition of the use of methods or means of warfare which are intended or may be expected to cause such damage to the natural environment and thereby to prejudice the health or survival of the population.*

Protocol on Non-Detectable Fragments (Protocol I). Geneva, 10 October 1980

> *It is prohibited to use any weapon the primary effect of which is to injure by fragments which in the human body escape detection by X-rays.*

Many of us in the United States today are fortunate. We have lived our lives in peace. War's violence has not disrupted our tranquil reality. Our comfort and sense of security has yet to be disturbed. Only by happenstance does hate, violence spawned by prejudice and intolerance, or crime provide a glimpse of what horrors human beings can inflict on one another. What knowledge we do possess of the darker side of life is served to us through the entertainment media. We witness endless acts of murder and violence but are protected by the knowledge that what is being enacted is for play and diversion. Our experience is not real. We sit in a darkened room and suspend disbelief in the drama unfolding before our eyes. Secure in this, we allow ourselves, as much as we dare, to experience every horrific deed that life has to offer. The mental gymnastics of this fantasy life has an effect on our perceptions of reality. We watch television news from the same habit of mind. The real starvation and brutality beamed into our living rooms is another show that we can turn off and make disappear. We're in control of its effect on our lives. We can keep it distant, letting it exist in some quasi-reality that need never intrude on our mundane concerns. Television networks conspire to keep the world's suffering at an unaffecting distance. Since Vietnam, news broadcasts sanitize life's horrors. The public no longer receives exposure to disturbing images. The hypnotic trance prevails. We remain asleep to the brute reality just beyond the horizon.

Our comfort and abundance cripples us. Empathy for the unfortunates of the world and their suffering has been lost. What we know of their tragedy comes to us through a dissociated portion of ourselves. Our own psychic numbing renders their pain unreal. We can applaud the show on television of precision bombs destroying their targets in Iraq or Kosovo without the bitter knowledge to spoil our dinners that wives will be waiting in vain

for their husbands killed in that bombing and children will never see their fathers again. The severed limbs from collapsing walls, the innocent victims at the wrong place at the wrong time bleeding out with pain and tears their last remaining moments, the charred bodies running until they collapse, these pitiful sights escape our eyes and fail to connect with the human tragedy of ruined lives that will endure after the cameras are turned off. We can drink another round of beers in the local bar for the mighty American war machine that thoroughly destroyed Iraq's armored vehicles with its depleted uranium munitions with total indifference to the aftermath. We give no thought to the tragedy of a child that happens upon an intact DU penetrator and takes it home as a toy and is diagnosed a few years later with cancer. Our compassion is not vivid enough to envision the suffering experienced by people whose only crime was to take a breath of air and in the process inhale uranium into their bodies. The slow debilitation of their health, the anxiety of not knowing what has beset them and why their lives will never be the same again, their broken hearts, their devastated lives — all this escapes our purview.

The tragedies of the Oklahoma City bombing and the destruction of the World Trade Center on 9/11 gave people of the United States a firsthand experience of horror and devastation. Everyone in the country shared the trauma of these events. The shock of the intrusion of barbarity into the mundane of our lives, the immediacy of the suffering of the victims, the horrific choice of our brethren as to whether to burn to death or plunge out of a skyscraper window: all these should remind us what our cruise missiles do to the lives of people, no different from ourselves, in other parts of the world. We can hit out in anger and revenge, but we must not overlook the fact that aerial bombing is incapable of selectively targeting terrorists to the exclusion of innocent bystanders. If we could see the deeds of our military through the eyes of those who suffer under its weapons, we might catch a glimpse of the ugly fact that our forces are servants of state-sponsored terrorism.

The crippling of our empathy insulates us from the horrors of war and immunizes us against the suffering of others. This handicap emboldens the intrigues of our statesmen and generals and makes us silent coconspirators in their misdeeds. Our leaders can pursue their objectives, inflict whatever degree of misery they deem desirable on whoever they select as their next enemy, without having to defend their crimes before the people who gave them their power. The outrage of the populace, or the threat of outrage, should ideally serve to check gross misconduct perpetrated by leadership. But if no outrage is felt, leadership is given license to maim and exterminate indiscriminately.

Our peace, security and abundance have been purchased at a terrible price. The guarantor of our freedom and prosperity is heinous evil. Thermonuclear weapons are our guardians. Silent and hidden, they vigilantly await the moment to disintegrate our enemies.

This merciless threat of annihilation under the most inhumane of circumstances is implicit in our democratic way of life. This is genocide, or the threat of genocide, as national policy. There is something wrong here, something disturbingly out of balance.

Humanity has been led into an unprecedented state of crisis by nuclear and radiological weapons. The very existence of these weapons is worldwide tyranny over all who are alive. Within each country that possesses these weapons, a tiny group of decision-makers can determine the fate of the Earth, the genetic integrity of all species and the homeostatic forces of our planet. This is terrible power. No human being can be entrusted to wield it. The human community needs to question whether this current state of affairs can continue to be tolerated. Can we afford to let the warriors and politicians retain such unprecedented power? Have they earned the trust to represent the best interests of humanity, for those alive today and those destined to be born into the far future? So we come back to a central question of this text yet again: Do the masses of humanity, out of power and out of the arena of decision-making, resign ourselves and our welfare to a community of statesmen who threaten us and our planet, or do we take unprecedented steps to assure ourselves that neither accident nor mischievous design rains down catastrophe?

In the tense and precarious predicament in which we find ourselves, it is instructive to ask whether international arrangements have been instituted to constrain governments from unleashing frightful weapons. What of international law? Is there some standard of conduct prescribed by treaties and agreements between nations that can intercede on behalf of humankind to rescue us from those who transgress against the human community?

Human beings wage war. Throughout history, we have been unable to overcome this predilection. The best we have been able to achieve is the observance of certain customs in warfare to regulate the conduct of battle and set limits to our barbarity. These informal initiatives over time evolved into the current body of international humanitarian law, one of the noblest undertakings of humankind. Humanitarian law is the embodiment of an ideal, long dreamt of by the innocent bystanders of combat, that human ferocity can be regulated by reason and the mutual observance of laws. It arose to curb both the primitive impulses within individuals to commit atrocities and the predatory belligerence of militaristic societies. This high achievement in political evolution is a fragile treasure, vulnerable to those nations who would flout the rule of law in the pursuit of selfish advantage over other nations. Today's dividing line between war and peace teeters on the willingness of all communities of human beings to conduct their affairs within the bounds of justice, compromise and lawfulness. Given this premise, we must ask how the use of depleted uranium weapons by the United States fits within the law of armed conflict adopted by the community of nations.

International humanitarian law, the law of armed conflict and the law of war are all different names referring to that body of international law which applies to the subject of war. The intent of this law is to set limits to the effects of armed conflict and introduce humanitarian principles into battle. It prescribes means and methods of warfare and provides guidelines intended to limit the injury and suffering to noncombatants as well as combatants who have laid down their arms. International humanitarian law addresses issues arising during conflict that are of humanitarian concern. It is not formulated to address the reasons for a conflict or its legality. Thus, it is intended to be adopted by all warring parties for their own self-interest, regardless of the reasons that provokes them into taking up arms. The law of war has evolved from a number of sources: the ancient customs of war, the numerous recorded treaties throughout history which themselves were expressions of pre-existing customary law, and legal decisions from major courts throughout the world. What has enabled such widespread acceptance of humanitarian laws based on these precedents is that they are in accordance with the general principles of law common to the many existing legal systems of the world.

Humankind's efforts to regulate its warring impulses are preserved in over 500 historical texts which document various cartels, codes of conduct, covenants, treaties and so forth. Codification of this body of legal precedent first began in the middle of the nineteenth century. The first modern international legal agreement, the First Geneva Convention, was drawn up and signed by 16 nations at the 1864 Diplomatic Conference convened by the Swiss government. This humanitarian initiative established protocols for the protection of wounded soldiers on the field of battle. The Hague Conventions which followed in 1899 and 1907 were further attempts to mitigate the atrocities of warfare. These first international agreements established the foundations for contemporary humanitarian law. Throughout the twentieth century, they were amended and expanded upon on a number of occasions.

Of particular importance, due to their almost universal adoption, are the four Geneva Conventions of August 12, 1949. These conventions address: (1) The amelioration of the condition of the wounded and sick in armed forces in the field. (2) The amelioration of the condition of the wounded, sick and shipwrecked members of armed forces at sea. (3) The treatment of prisoners of war. (4) The protection of civilian persons in time of war. As of 2002, 189 nations had voluntarily bound themselves under the Geneva Conventions. These conventions were supplemented by the two Additional Protocols of 1977. Protocol I concerns the protection of victims of international armed conflicts, and Protocol II addresses the protection of victims of non-international armed conflicts. Additional supplementation to these agreements has been enacted through the adoption of other treaties, conventions and protocols. For instance, the *Convention on the Prohibition of*

Military or Any Hostile Use of Environmental Modification Techniques was adopted in 1976. In 1980, ratification was achieved of the *Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May be Deemed to be Excessively Injurious or to Have Indiscriminate Effects*. Produced in the same year was the *Protocol on Non-Detectable Fragments*. In 1993, the *Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and Their Destruction* was signed. Additional protocols have been drafted to prohibit the use of particular kinds of weapon systems such as asphyxiating, poisonous and other gases; bacteriological agents; mines, booby-traps and other such devices; incendiary weapons and blinding lasers.

The International Committee of the Red Cross, in order to promote greater understanding and acceptance of humanitarian law, has summarized its basic principles as follows:

1. The belligerents in armed conflicts must make every effort to distinguish between civilian populations and combatants.
2. Neither the civilian population as a whole nor individual civilians may be the target of aggression.
3. Civilian property is to be preserved.
4. Attacks shall only be directed against military objectives.
5. Neither warring parties nor members of their armed forces have an unlimited choice of methods and means of warfare.
6. Weapons may not be used or methods of warfare undertaken that will cause unnecessary injury or death or excessive suffering.
7. It is forbidden to kill or wound an enemy combatant who is disabled, who has laid down his arms and withdrawn from fighting or who has surrendered.
8. Civilians and people who no longer participate in hostilities are to be treated humanely and are entitled to respect for their lives and their mental and physical integrity.
9. The wounded and sick must be collected and given medical care by the party in the conflict that has them in its power.
10. Medical personnel, medical equipment, medical transports and medical facilities must not be targeted.
11. Captured combatants are protected against acts of violence or reprisal.
12. Captured combatants and civilians under the authority of an adverse party are entitled to respect for their lives; their dignity; their personal rights; and their political, religious and other convictions.
13. Captured combatants and civilians are entitled to the benefit from fundamental judicial guarantees. No one shall be held responsible for an act he has not committed.

14. No one shall be subjected to physical or mental torture, corporal punishment, or cruel or degrading treatment.
15. Captives are entitled to exchange news with their families and receive aid.

If circumstances of warfare arise that are not specifically addressed by treaty obligations or customary humanitarian law, a general principle known as the Martens Clause provides legal guidelines. Authored by Fyodor Martens in 1899, it appears in the preamble to the Hague Convention *Respecting the Laws and Customs of War on Land*:

> Until a more complete code of laws of war has been issued, the High Contracting Parties deem it expedient to declare that, in cases not included in the Regulations adopted by them, the civilians and the combatants remain under the protection and the authority of the principles of international law derived from established custom, from the principles of humanity, and the dictates of the public conscience.

This principle, which came to be considered as part of customary law after its first appearance, was formally incorporated into international law in 1977 as part of Additional Protocol I to the Geneva Conventions. Although lawyers involved with humanitarian issues argue over the precise legal meanings inherent in the Martens Clause, the principle it represents is straightforward. Treaty provisions are not the sole basis for humanitarian law. If some new weapon, means or method of warfare is not specifically prohibited by a provision within a treaty, this in itself does not make that weapon, means or method of warfare permissible. In the absence of treaty provisions, the legality of military operations, weapons systems, the treatment of victims and so forth must be determined by existing law and the customs of war. This includes international customary law, the principles of humanity and the dictates of the public conscience.

Regarding weapons containing depleted uranium, the United States government has adopted the position that uranium weapons are legal because no law exists prohibiting their use and no international treaty exists specifically banning these weapons. Further, it staunchly and adamantly maintains that uranium weapons are conventional weapons, not radiological weapons. It denies all claims that these weapons produce any radiological effects in human beings. The United States is forced to stand its ground on this issue in order to justify the legality of the use of DU. A radiological effect would put it in violation of numerous treaty provisions. For instance, weapons are prohibited which produce fragments that are undetectable by x-rays; produce indiscriminate effects; cause superfluous injury or unnecessary suffering; or cause widespread, long-term and severe damage to the natural environment. Further, by acknowledging the radiological nature of uranium weapons, the United States would simultaneously be admitting culpability for radiation-

induced injuries and environmental contamination and make itself liable for any financial compensation sought.

Since 1996, the position the United States has taken on uranium weapons has been challenged at the United Nations. This initiative was spearheaded by the International Educational Development/Humanitarian Law Project, a nongovernmental organization accredited by the United Nations Economic and Social Council. Chief spokeswoman for this group is Karen Parker, an attorney based in San Francisco, who specializes in human rights and humanitarian law. The position she has presented to the UN is twofold. First, uranium weapons are already illegal under existing human rights law, humanitarian law and the customs of war. Second, that the forums within the United Nations dealing with human rights issues are the appropriate platforms for dealing with this illegality. To justify this position, Parker has framed a powerful legal argument.

According to Parker, the legality or illegality of a weapon is established in two ways. First a weapon may be made illegal and banned from combat through the drafting and ratification of a treaty specifically banning the weapon in question. In this circumstance, the weapon is only illegal for the signatory nations to the treaty. All countries refusing to ratify the treaty are not legally bound to refrain from using the weapon in combat. A second way to establish the legal status of a weapon is to determine whether or not when used it violates existing law or the customs of war. If by this method a weapon is found to be illegal, it is illegal for all countries. This is true even in the case when a treaty concerning the weapon has been instituted and a country has not ratified that particular treaty. To establish the legality or illegality of a weapon by the second method, all of humanitarian law must be taken into account. Parker writes:

> The laws and customs of war (humanitarian law) includes all treaties governing military operations, weapons and protection of victims of war as well as all customary international law on these subjects. In other words, in evaluating whether a particular weapon is legal or illegal when there is not a specific treaty, the whole of humanitarian law must be consulted (Parker).

According to Parker's reading of the Martens clause, determination of the legality of new types of weapons can be determined by the Rule of Analogy:

> To accommodate the fact that methods and means of warfare evolve with time, the drafters of treaties on humanitarian law incorporated the rule that a new method or means of warfare may be deemed illegal if it is similar to methods or means of warfare that are expressly

> or by custom prohibited. This is called the rule of analogy.
>
> Applying this rule to any new weapons requires review of both all other treaties forbidding particular weapons as well as all of the rest of humanitarian and human rights law. In review of a treaty prohibiting a specific weapons, the question should be asked "why was that weapon prohibited?" If a new weapon has a similar effect, then it may be sufficiently "analogous" to be also prohibited.
>
> Use of the rule by analogy buttresses the argument that weapons containing depleted uranium (DU) are already illegal — a conclusion of the United Nation Sub-Commissions and Justice Sik Yuen in particular. Arguments could be put forward that DU weapons are "poison" or "poisonous" and thus banned by the Hague Convention of 1907, Regulations Article XXIII(a). While clearly not foreseen in 1907, DU weapons have an effect on the human body and natural environment that is "analogous" to the poisons of 1907. In a similar vein, the 1925 Protocol on Gases may ban DU weapons because they are analogous to those specifically mentioned in the treaty. And regardless of whether one considers DU weapons conventional or nuclear or radiological, the 1980 Conventional Weapons Convention, Protocol I prohibits weapons producing fragments not detectable by X-rays. If one considers DU weapons conventional then this provision directly applies. If one considers DU weapons nuclear or radiological, then this provisions prohibits them by analogy because DU particles are not detectable by x-rays (Parker, Addenda).

Applying the Rule of Analogy to the laws and customs of war, Parker has succinctly outlined why weapons fabricated from depleted uranium are clearly illegal:

> There are four rules derived from the whole of humanitarian law regarding weapons:
>
> (1) Weapons may only be used in the legal field of battle, defined as legal military targets of the enemy in the war. Weapons may not have an adverse effect off the legal field of battle. (The "territorial" test).
>
> (2) Weapons can only be used for the duration of an armed conflict. A weapon that is used or continues to act after the war is over violates this criterion. (The "temporal" test).
>
> (3) Weapons may not be unduly inhumane. (The "humaneness" test).

> The Hague Conventions of 1899 and 1907 use the terms 'unnecessary suffering' and 'superfluous injury' for this concept.
>
> (4) Weapons may not have an unduly negative effect on the natural environment. (The "environmental" test).
>
> DU weaponry fails all four tests. (1) It cannot be "contained" to legal fields of battle and thus fails the territorial test. Instead the DU is airborne far afield of legal targets to illegal (civilian) targets: hospitals, schools, civilian dwellings and even neighboring countries with which the user is not at war. (2) It cannot be turned off when the war is over. Instead, DU weaponry continues to act after hostilities are over and thus fail the temporal test. Even with rigorous cleanup of war zones, the airborne particles have a half-life of billions of years and have potential to keep killing and injuring former combatants and noncombatants long after the war is over. (3) It is inhumane and thus fails the humaneness test. DU weaponry is inhumane because of how it can kill — by cancer, kidney disease, etc. — and long after the hostilities are over when the killing must stop. DU is inhumane because it can cause birth (genetic) defects such as cranial facial anomalies, missing limbs, grossly deformed and nonviable infants and the like, thus affecting children who may never be a military target and who are born after the war is over. The tetragenic nature of DU weapons and the possible burdening of the gene pool of future generations raise the possibility that the use of DU weaponry is genocide. (4) It cannot be used without unduly damaging the natural environment and thus fails the environment test. Damage to the natural environment includes contamination of water and agricultural land necessary for the subsistence of the civilian population far beyond the lifetime of that population. Cleanup is an inexact science and, in any case, extremely expensive — far beyond the ability of a poor country to pay for (Parker).

Karen Parker's argument on the illegality of depleted uranium weaponry is persuasive. It convincingly argues the point that the use of DU in warfare is already prohibited by international humanitarian law. This conclusion is further bolstered by a cursory reading of excerpts from the numerous conventions and protocols that have been widely adopted by the international community of nations. But, there are two sides to every legal argument. The devil must be given his due. Thus, it is necessary to examine the legal arguments that could be used by the United States to justify its claim that depleted uranium use is not prohibited under current international law.

Depleted uranium weapons, by their very nature, are devious instruments. Developed by devious minds, they were introduced into warfare in a devious fashion. Likewise, the arguments defending their legality are equally devious. However, by the letter of the law, these arguments are forceful and connivingly convincing.

The International Legality of Depleted Uranium, freely available on the internet, is a deftly written article on the legal issues surrounding the use of DU in combat. Written by Avril McDonald, it comprehensively explores relevant aspects of humanitarian law that might apply to DU weapons and clarifies numerous legal issues pertinent to these munitions. What follows is a brief examination of some of the arguments put forth within this document that could be used by the United States to defend its position that the use of DU does not violate humanitarian law.

When examining the legality of depleted uranium munitions, a prudent first step is to establish to what class of weapon these belong. By examining the definition of weapons that are expressly banned by current international humanitarian law, a straightforward answer may be forthcoming as to the legality of DU.

To begin, can it be said that weapons fabricated with depleted uranium are chemical weapons? To answer this question, we need to refer to the 1993 *Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction*. According to Article 2(1)(b), chemical weapons are munitions and devices specifically designed to cause death or other harm through the toxic properties of the chemical(s) they contain and which would be released as the result of the employment of the munition or device. The meaning of "toxic chemical" is defined in Article 2(2): "Any chemical which through its chemical action on life processes can cause death, temporary incapacitation or permanent harm to humans or animals. This includes all such chemicals, regardless of their origin or of their method of production, and regardless of whether they are produced in facilities, in munitions or elsewhere."

Adhering to the letter of the law, defenders of DU weapons will argue that these munitions are not ***specifically*** designed to cause death or harm by the chemical properties of uranium. Their fundamental purpose is to penetrate and destroy armor and other hardened targets. This argument may be sufficient to prevent its classification as a chemical weapon *even though these munitions simultaneously produce a chemical effect*. Arguing by analogy, DU apologists will argue that lead is a chemically toxic heavy metal that can poison those wounded by it, but its use is not prohibited in armaments. To further strengthen their argument, they will reference the numerous tomes penned by "impeccable" researchers and institutions that categorically deny the chemical and radiological hazards of uranium. By

this means, it will be "proven" that DU is incapable of causing "death, temporary incapacitation or permanent harm." Without vocal, worldwide opposition to this type of end run around the legal understanding of a chemical weapon, depleted uranium will not be seen as prohibited by the Chemical Weapon Convention.

Well, if DU isn't a chemical weapon, is it a biological weapon? According to the 1975 *Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and their Destruction*, biological weapons employ:

> Microbial or other biological agents, or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes.

Clearly, although DU produces certain biological effects, it does not fall within the definition of a biological weapon. In addition, a reasonable argument can be framed to justify its prophylactic, protective and peaceful use.

Pursuing this investigation further, can it be argued that depleted uranium munitions are non-nuclear, radiological weapons? The radiological properties of uranium are beyond dispute. The US insists, however, that the primary function of DU is to penetrate hardened targets and that their radiation is incidental to their purpose. Further, it is nonhazardous. Although this author believes this argument to be disingenuous, a worldwide consensus has yet to crystalize to the effect that what the US is actually doing with these weapons is incapacitating enemy populations by radiological warfare. In any case, the US is buffered against such criticism by the fact that there currently are no conventions banning radiological weapons.

To be a human being is embarrassing when first learning that, according to international law, nuclear weapons are not illegal. No convention has been drafted to prohibit their use. According to McDonald:

> The 1996 Advisory Opinions of the International Court of Justice concerning Nuclear Weapons did not rule out the possibility of a use of nuclear weapons by a state acting in self-defence where the very existence of the state was at stake. In the absence of specific customary or conventional prohibitions on the use of nuclear weapons, the Court was not ready to conclude that their use 'would necessarily be at variance with the principles and rules of law applicable in armed conflicts in any circumstance.'

Thus, even if one could stretch the definition of a nuclear weapon to encompass

DU, this would not help one iota in prohibiting its use. As currently construed under the law, Armageddon might be perfectly legal! This absurdity should in itself prove the point that legal instruments are not ready to defend humanity from those amongst us who revel in destruction.

In accordance with public statements made by representatives of the US Government, depleted uranium weapons most closely fall within the definition of conventional weapons. These weapons are governed by the 1980 *Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May Be Deemed to Be Excessively Injurious or to Have Indiscriminate Effects*. The various protocols under this convention prohibit the use of mines and booby-traps, incendiary weapons, blinding laser weapons and weapons which injure by producing non-detectable fragments. It might be argued that due to their pyrophoric nature, depleted uranium munitions should be classified as incendiary weapons. But a careful reading of the convention puts this in doubt:

> Protocol III on Prohibitions or Restrictions on the Use of Incendiary Weapons prohibits, in all circumstances, making the civilian population as such, individual civilians or civilian objects, the object of attack by any weapon or munition which is primarily designed to set fire to objects or to cause burn injury to persons through the action of flame, heat or a combination thereof, produced by a chemical reaction of a substance delivered on the target.

By the legalese used to formulate this definition, it is evident that depleted uranium cannot be classified as an incendiary weapon. Its *primary* design, at least according to military propaganda, is not to set fire to objects or to cause burn injury. Although DU penetrators are incendiary, this is considered a secondary effect to its primary purpose of destroying armor. The *Protocol on Prohibitions or Restrictions on the Use of Incendiary Weapons* explicitly permits this effect:

> Incendiary weapons do not include: (i) Munitions which may have incidental incendiary effects, such as illuminants, tracers, smoke or signaling systems; (ii) Munitions designed to combine penetration, blast or fragmentation effects with an additional incendiary effect, such as armor-piercing projectiles, fragmentation shells, explosive bombs and similar combined-effects munitions in which the incendiary effect is not specifically designed to cause burn injury to persons, but to be used against military objectives, such as armored vehicles, aircraft and installations or facilities.

By this definition, the US is operating within the law as long as DU munitions are

directed against hardened military targets, even if by their incendiary nature civilians and civilian targets are inadvertently consumed in fire. The US would be in violation of this Protocol only if DU weapons were intentionally used against civilians and nonmilitary targets.

Protocol I of the previously cited 1980 Convention on Conventional Weapons is the one provision within international law that most closely condemns the use of depleted uranium weapons. This *Protocol on Non-Detectable Fragments* states: "It is prohibited to use any weapon the primary effect of which is to injure by fragments which in the human body escape detection by X-rays." This Protocol was ratified by the United States on March 24, 1995. Clearly, DU weapons deposit micron-sized particles of uranium in the human body that would escape detection by x-rays. Advocates for these weapons, however, will once again point out that deposition of these fragments within the body is not the primary effect of these weapons and that it is questionable whether DU fragments produce adverse chemical and radiological effects on human physiology.

Having examined the international treaties that specifically outlaw particular types of weapons, we have discovered that DU munitions fall between the cracks. Apparently, they are not illegal despite the fact that they are incendiary, produce non-detectable fragments, produce toxic chemicals that are inhaled into the human body, emit radiation to cells in the body's interior and induce biologically deleterious effects. To reiterate, depleted uranium weapons are devious instruments. Inadequate legal mechanisms leave humanity vulnerable to crimes that are not crimes.

If international humanitarian law does not currently prohibit DU weapons, the question still remains as to whether or not their use violates basic humanitarian principles inherent in customary law. According to McDonald:

> The relevant provisions of international humanitarian law as set out above [excerpts from the Geneva Conventions and Additional Protocol I] are encapsulated in a number of core general principles, which are widely accepted as having the status of customary international law, meaning that they apply to all states and all individuals engaged in combat even if those states are not actually States Parties to the Geneva Conventions and their Additional Protocols. The fact that these general rules do have the status of customary law is particularly important considering that the US, the state that has most often used DU weapons, is not a State Party to Additional Protocol I. The relevant general principles are:

a. Distinction/prohibition against indiscriminate attacks
b. Military necessity
c. Superfluous injury and unnecessary suffering
d. Proportionality
e. Precaution
f. The principle of humanity – the Martens Clause

Legal minds, intent on justifying the continued dumping of radioactivity on other peoples' homeland, will have a field day arguing that DU armaments are in perfect harmony with customary law. For instance, the prohibition against indiscriminate attack refers to the principle that civilians are to be protected from the hazards of combat. To this end, those waging war are obligated to restrict their attacks to combatants and military targets and protect from danger non-combatants and the civilian infrastructure that sustains them. Specifically, according to Article 51 of Additional Protocol I, indiscriminate attacks are prohibited. These are defined as:

> (a) those which are not directed at a specific military objective;
>
> (b) those which employ a method or means of combat which cannot be directed against a specific military objective; or
>
> (c) those which employ a method or means of combat the effects which cannot be limited as required by this Protocol; and consequently, in each such case, are of a nature to strike military objectives and civilians or civilian objectives without distinction.

A cogent argument can be framed that depleted uranium weapons, as currently deployed, do not constitute indiscriminate attack. As far as is known, they are fired in combat to achieve a well-defined military objective, i.e., to destroy hardened or armored military targets. They are not, at least to all appearances, used as part of a deliberate direct attack on civilians. (Due to their duplicitous nature, depleted uranium weapons may in fact be in use for the purpose of eroding the health of civilians, but it would be hard to prove this when faced with the plausible denial of the Pentagon.) According to McDonald, what is prohibited is "attacks" against civilians, not the effects of DU *per se*:

> It would be stretching the meaning of the paragraph [Article 51(2)] too far to consider the use of DU in itself as constituting an attack on the civilian population, where it is directed at a military objective and its effects on the civilian population are incidental to the achievement of the military objective, which is to penetrate armored vehicles. Neither can the use of DU, under any reasonable analysis and in light

> of the intended meaning, be considered as an act of violence the primary purpose of which is to spread terror.

Those responsible for codifying humanitarian law are not oblivious to the realities of combat. In an attack on military targets, the possibility of "collateral" damage to civilians is an acknowledged fact. What would make an attack "indiscriminate" would be, as stated in under Article 51(5)(b), an attack which "may be expected to cause incidental loss of civilian life, injury to civilians, or a combination thereof, which would be excessive in relation to the concrete and direct military advantage anticipated." Due to a lack of consensus among "experts" on the medical effects of depleted uranium, there is no way at this time to prove that harm to the civilian population, future generations or the environment is "excessive." For the same reasons, it is not possible to argue that an attack with DU is indiscriminate because its effects are not limited to the battlefield. Without widely accepted, unambiguous scientific evidence that DU is responsible for debilitated health, birth defects and environmental degradation, adverse effects to civilians is unsupported conjecture.

The next principle of customary law that needs to be examined is whether or not depleted uranium weapons fulfill a military necessity that cannot be accomplished by other types of weapons which are less threatening to the civilian population. Defenders of DU will point out that, for at least certain types of missions, these weapons are irreplaceable and thus necessary to winning a campaign. Certainly, there is an element of truth to this argument. However, it is weakened by the fact that tungsten could be used in place of DU without a significant sacrifice in the capability of penetrating and destroying hardened targets. It also could be argued that tungsten is more humane than DU because it is not pyrophoric and would thus produce fewer casualties from burning and suffocation. However, since these casualties are inflicted against combatants, considerations of humanitarian law might not be relevant.

By the principles of customary law, do depleted uranium weapons create superfluous injury or unnecessary suffering? According to McDonald, for weapons to be prohibited from producing such effects, it is necessary to prove that these effects are a feature of their design, that these weapons are purposely engineered to create superfluous injury or unnecessary suffering. How can this be proven? The government insists that these weapons are designed for destroying hardened targets to the exclusion of all other effects. Government denies, denies, denies that DU can adversely affect healthy human functioning. This duplicity has successfully served the American war machine. It confounds critics of DU weapons and disarms the most cogent argument that these armaments are illegal and immoral.

What provides the strongest defense for depleted uranium is the corrupted science

of radiation effects and the paucity of relevant research on ailing populations exposed to DU. These obstacles have hindered the formation of a consensus of opinion within the scientific community and among the general public. As a consequence, the point is highly contentious as to whether DU munitions produce superfluous injury and unnecessary suffering. McDonald writes:

> Despite the growing amount of scientific and medical research into the health effects of DU, and evidence that there is reason to be concerned about its impact on both health and the environment, medical and scientific experts are still unsure of the mid- to long-term effects of exposure to DU. Since it is impossible at the current time to make a fully-informed assessment of the impact on the civilian population, as well as on combatants, of the use of DU, it would be premature to reach any definite conclusions about whether the use of DU munitions contravenes any principle or rule of international humanitarian law. Moreover, it is not possible to judge in the abstract and outside a specific situation of armed conflict whether the use of DU munitions would be disproportionate, or indiscriminate or whether they would cause superfluous injury or unnecessary suffering.

As we have witnessed elsewhere in this book, a solid edifice of so-called reputable institutions is in place worldwide which testify that DU represents minimal hazard to human health and the environment. This fraternity serves a strategic purpose in maintaining the legality of depleted uranium weapons. By their testimony, DU does not produce superfluous injury and unnecessary suffering. By their testimony, the effects of DU are not out of proportion to military necessity. By their testimony, the use of DU does not require precautionary measures. By their testimony, DU contamination does not violate human rights law because no one's health is being compromised. By their testimony, international criminal law is not being violated by the perpetration of DU crimes against humanity. Consequently, the use of depleted uranium is not in violation of the Martens Clause because it does not violate the laws of humanity and the dictates of public conscience. Depleted uranium weapons retain their legality by means of the bastardization of the science of low-dose radiation effects of internal emitters.

It should now be apparent why the United States cannot sponsor honest and comprehensive research on veterans as to the true effects of DU on human health. Unambiguous, scientific fact about DU hazards would condemn the actions of the US military as criminal. The US would be legally obligated to compensate victims and clean up contaminated environments. Control of what people believe to be true also controls what they believe to be legal. This in turn determines what they believe their rights to be.

One final aspect of law that needs to be examined is international environmental law. Is the dispersal of depleted uranium throughout the environment prohibited? In Article 35(3) of Additional Protocol I, the following provision is included:

> It is prohibited to employ methods or means of warfare which are intended, or may be expected, to cause widespread, long-term and severe damage to the environment.

Article 55 of the same document states the following:

> Care shall be taken in warfare to protect the natural environment against widespread, long-term and severe damage. This protection includes a prohibition of the use of methods or means of warfare which are intended or may be expected to cause such damage to the natural environment and thereby to prejudice the health or survival of the population

The fundamental problem with the wording of these two sections is that they leave vague and open to interpretation the meaning of "widespread, long-term and severe damage." Coupled with the uncertainty of DU's impact on the environment, condemnation of the weapons under this statute is not a foregone conclusion. McDonald states that according to the International Committee of the Red Cross, drafters of Additional Protocol I had in mind the disruption of the ecosystem. This concept may prohibit, at least under some circumstances, nuclear weapons, but can the same be said for depleted uranium? Further, does DU contamination "prejudice the health and survival of the population?" This refers to a high level of alteration of the environment which may not fully result from uranium contamination.

In Additional Protocol I of the Geneva Conventions, Article 36 includes the following provision, which addresses the development of novel weapon systems:

> In the study, development, acquisition or adoption of a new weapon, means or method of warfare, a High Contracting Party is under an obligation to determine whether its employment would, in some or all circumstances, be prohibited by this Protocol or by any other rule of international law applicable to the High Contracting Party.

Although the United States is not a signatory of Additional Protocol I, it has nevertheless conducted two reviews of international law to assess the legality of using depleted uranium weapons in combat. The first was conducted by the Air Force in 1975. This study

was conducted to ascertain the legality of using 30 mm ammunition containing DU in the GAU-8 gun mounted on the A-10 "Warthog" aircraft. According to McDonald, "The review examined the legality of DU under three applicable principles of international law: (1) The prohibition of unnecessary suffering. (2) The prohibition of poison. (3) The principle of proportionality/prohibition of indiscriminate effects."

According to the assessment of the Air Force:

> In general, the prohibition against unnecessary suffering, and the general policy behind it, more significantly affects weapons primarily directed against personnel rather than material targets. (…) Weapons with designated characteristics necessary in terms of the target attacked, such as armor piercing shells, remain lawful even though they might cause a higher order of suffering than other weapons. Nevertheless, in view of the fundamental principle of unnecessary suffering which applies to the manner which otherwise lawful weapons are used, depleted uranium munitions should not be directed solely against persons if alternate weapons are available and can be used (McDonald).

The Air Force review openly acknowledges the incendiary nature of depleted uranium. For this reason, it advises that the use of DU ammunition should be restricted to military targets and not directed against civilian populations. This conclusion differs from what is included in the Conventional Weapons Convention of 1980. There, armor-piercing projectiles are not considered incendiary weapons because the fires they produce, and the burns to combatants which result, are incidental to the purpose for which they are designed, that is, the destruction of hardened targets.

The Air Force recognized that it would be vulnerable to criticism that it was deploying poisonous weapons if DU came to be used in antipersonnel weapons. Again, it stipulated that as long as DU munitions were specifically used against armored targets, their use would not violate provisions against poisons:

> Several factors support this conclusion. DU's toxic radiological and chemical properties are an inherent characteristic of the substance and not a designed, added in, characteristic. (…) In addition, the choice of this substance is based on provable cost and efficiency factors, and its significant injury producing effects stem from its fragment kinetic effects. These kinetic effects are more significant than any long range toxicity consideration, which are in any event found in other weapons such as lead. Soluble depleted uranium compounds are not

> considered to be a significant radiation hazard and its toxicity is due primarily to its chemical properties. Uranium does not appear to be any more chemically toxic than lead. Moreover, the depleted uranium munitions are designed to be used against hard targets, and depleted uranium is selected and used for this purpose. For reasons related to the prohibition against unnecessary suffering and poison, the following specific restriction on use should be adopted for this munition. "This munition is designed for use against tanks, armored personnel carriers or other hard targets. Use of this munition solely against personnel is prohibited if alternate weapons are available (McDonald).

The Air Force review acknowledges that the effects of a weapon when used in a combat situation cannot always be controlled. Escape from control of the user both in time and space can potentially cause disproportionate injury to civilians and be judged an indiscriminate attack. Consequently, the review recommends that before DU munitions are deployed, consideration should be given to the geographical conditions in which a target is located. For instance, due to its incendiary nature, it advises that depleted uranium weapons should not be used where spreading fires will create disproportionate and indiscriminate injury to civilians and civilian infrastructure. The same consideration is urged due to DU's radiological properties:

> The risk of injury to civilian populations from the radiological effects of depleted uranium munitions depends more upon the extent of its use in a particular conflict or given geographical area. The findings of the working group note that significant impact can occur in the event of uncontrolled use of DU depending upon local conditions. These risks occur both due to chemical and radiological properties. The working group study notes that in combat situations involving the widespread use of DU munitions, the potential for inhalation, ingestion, or implantation may be locally significant. The risks are noted to be insignificant when compared with other dangers of combat. These risks, of course, are potentially dangerous to friendly civilian populations as well as enemy populations. In general, we cannot perceive that these risks are necessarily disproportionate to the military advantages secured by use of this munition particularly if its use is restricted, to the extent possible, to its intended use against hard targets.

What must not be overlooked in this statement is that the Air Force unambiguously acknowledges the radiological nature of depleted uranium and warns that this can create

risks to civilians under certain geographical conditions. In light of this observation, it is troubling that depleted uranium has been detected in urban areas such as Kabul in Afghanistan and Baghdad in Iraq. Clearly, the US is electing to target military installations in dense population areas with DU weapons. This will invariably create internal contamination to local residents. However, it is unlikely that the discovery of urban befoulment with DU will spur greater opposition to these weapons. If anything, it will only open up another legal debate as to whether or not the effects on human health being produced are disproportionate to the military benefit derived from these weapons when used in populated areas.

In 1994, the US Department of the Army conducted a second review of the legality of depleted uranium weapons. This review centered on the legality of the 120 mm M829A2 Cartridge for the M256 cannon used on the M1A1 and M1A2 Abrams Main Battle Tank. Again, the possible poisonous nature of DU was examined as well as its potential for causing superfluous injury and unnecessary suffering.

According to the Army, determination of whether or not a weapon causes superfluous injury or unnecessary suffering is made by assessing the proportionality of its effects to its military necessity, and further, by comparing these effects to the degree of injury produced by other lawful weapons. In regards to the DU cartridge in question, the Army concluded that when used to destroy military objectives, the low-level radiation emitted by uranium could not produce disproportionate effects. According to the Army review:

> DU is treated as low-level radioactive material and, when discarded, is considered a low-level radioactive waste. It fits into the lowest low-level radioactive waste hazard class. Radiological exposure to external sources of DU occurs through the proximity of personnel to munitions, armor and contaminated equipment. These are low-level, low dose-rate exposures that are within current safety and health standards of the US Nuclear Regulatory Commission (NRC).
>
> DU provides a substantial performance advantage, well above other competing materials such as tungsten steel. This enables DU penetrators to defeat an armored target at a significantly greater distance. The greater penetration capability of DU is the military necessity for its use. DU is not employed to increase the suffering of individual enemy combatants, and there is no evidence that DU increases combatant suffering (McDonald).

Addressing the possibility that DU might be considered a poison, the Army review

quoted a report published by the Army Environmental Policy Institute *after* Operation Desert Storm. This report concluded that the hazards of DU contamination on the battlefield was probably small, that the environmental impact was low, and the long-term health effects of embedded DU fragments were minimal. The Army's review concluded with the following observation:

> Post-Desert Storm studies by environmental and health officials conclude that the health risk in the use of DU is negligible. DU ammunition violates neither the customary law of war prohibitions on unnecessary suffering and poison or poisonous materials, or the new prohibitions contained in the 1977 Additional Protocol I against methods or means of warfare that are intended, or may be expected, to cause widespread, long-term and severe damage to the natural environment. [Thus] the M829A2 Cartridge, 120 mm, APFSDS-T Depleted Uranium Tank Round is consistent with the law of war obligations of the United States (McDonald).

Malefactors the world over must come and study at the feet of those who conceived depleted uranium weapons. The ambiguous nature of these arms allows criminality to openly parade upon the Earth as unimpeachable legality. This brilliant stratagem is not uncalculated. The United States has much to lose if judged outside the law. The stakes at play are succinctly elucidated by Karen Parker:

> Under international law, there are a number of requirements to remedy breaches of the Geneva Conventions and other rules forming the laws and customs of war. A minimum requirement of the duty to remedy from use of illegal weaponry is compensation for victims. This can include, for example, military and civilian victims from wars and depleted uranium weaponry use at military ranges. Part of the minimum remedy is the duty to disclose fully all facts about the weapons and their development and deployment. Regarding environmental damages, users of these weapons are obligated to carry out an effective cleanup. When lands and water resources cannot be effectively cleaned up, the State causing the damage must pay damages equal to the loss of those lands and waters from the national patrimony. In US dollars, the cost of legal claims and environmental cleanup for the Gulf Wars alone could be staggering.
>
> In addition to liability for damages to victims or the environment, users of DU weapons should face penal sanctions under existing humanitarian law provisions. For example, the Geneva Conventions

> of 1949 require that signatory States have domestic legal mechanisms for trying persons alleged to have committed serious violations of humanitarian law. Article 146 further states that all signatory states have a duty to search for alleged violators and to bring them to its own tribunals, regardless of their nationality. Article 148 prohibits any State from absolving itself or any other State from liability for serious violations (Parker).

What power is going to call the United States to account for its criminal misuse of depleted uranium? How will reparations ever be extracted? The law is impotent.

The whole point of this exercise has been to demonstrate that the law, with all its fine words, is not going to intercede for humanity to protect it from wicked people who wield wicked weapons. Humanitarian law is crippled by the absence of an unbiased mechanism of enforcement. No power exists on Earth to dissuade a superpower from trodding upon whoever it deems expendable. At some point in the future, remedy for this deficiency will be sought in the establishment of a New World Order by a one-world government. To humanity's loss, those who will propose this solution will be the same criminals who are today terrorizing the innocents with hellish weapons. Human affairs are being herded by state-sponsored terrorism and destruction. No mechanism remains to rescue humanity except massive, unbridled outrage at the crimes of today that are masquerading as overtures to peace. Humankind will have to dismantle the institutions that are abusing its own welfare in order for justice to finally take root.

19

The Eternal Bequest of the Cult of Nuclearists

Humanity has crossed a threshold. The United States, with its uranium and depleted uranium munitions, has fired the opening salvo of radiological warfare against the Earth and its creatures. We stand only at the beginning. Future battlefields all over the globe, which today nurture life, wait silently to be transformed into repositories for radioactive waste. Currently, the US exports depleted uranium to at least 16 other countries. The benefit, in the short term, of this dissemination is twofold: (1) Our homeland inventory of radioactive contaminants is reduced. (2) The ubiquitous presence of uranium weaponry in arsenals around the globe makes its control or condemnation difficult if not impossible. The precedent has been established. As long as armies collide, radioactivity will be cast into the biosphere. This is the legacy the Cult of Nuclearists is bequeathing to posterity.

Some perspective is required to fully appreciate the scope of what is being perpetrated. Imagine extraterrestrial explorers, a million years hence, arriving on Earth. To glean something of the history of our planet, they begin to undertake widespread geological investigations. Core samples of the layer of rock corresponding to our geological era will reveal to them a peculiar dispersal pattern of uranium isotopes. Regardless of the native rock of a local area, interspersed within it will be minute concentrations of uranium. Isotope analysis will reveal that the proportions between uranium-238 and uranium-235 are unnatural compared to those found deeper in the geologic strata. Further, the telltale presence of uranium-236, which does not exist naturally on the Earth, will enlighten these visitors as to the fact that an intelligent species once walked upon this orb and was technologically advanced enough to at least crudely manipulate nuclear energy. Such findings will fill

these explorers with speculation as to what prompted the creatures that once dwelt here to despoil their home.

The Cult of Nuclearists is leaving its indelible signature upon the Earth. Decision-makers in power today are imprinting their deeds in the geology of our planet. When all of our species and all of our cultural achievements have returned to dust, we will only be rediscovered and memorialized by the radioactive inheritance being broadcast over the Earth today. In the future, knowledge of our entire species will be reduced to the actions of a handful of ruthless men. *We will be known by their deeds*. As long as planet Earth endures, the intentions of the Cult of Nuclearists will endure even when all other traces of *Homo sapiens* have vanished.

By their deeds, you will know them.

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